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AMERICAN SOCIETY
FOR
TESTING MATERIALS

**AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS**

**REPORTS OF THE COMMITTEE
ON PRESERVATIVE COATINGS FOR
STRUCTURAL MATERIALS**

1903-1913

**REPRINTED FROM VOLUMES III-XIII OF THE COPYRIGHTED
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UNDER THE REGULATIONS GOVERNING PUBLICATIONS**

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SCHOOL OF ENGINEERING.

PREFACE

The American Society for Testing Materials dates its organization from the formation in Philadelphia on June 16, 1898, of the American Section of the International Association for Testing Materials. At the meeting held in June, 1902, the American Section resolved itself into the American Society for Testing Materials, incorporated under the laws of Pennsylvania.

At the third session of this 1902 meeting, the following resolution was adopted:

"Resolved, That the Chairman of this Convention appoint a committee of at least six members of this Society for the purpose of gathering statistics, making experiments and testing in numerous ways the different materials offered for sale in the open market for the purpose of protecting steel against corrosion, and for recommending some means of disposing of the mill scale without causing unusual expense and delay to the assemblers. Also to recommend a set of specifications for the application of the preservative to the steel, same to be reported at the next Annual Meeting."

Following this meeting, the Executive Committee created "Committee E on Preservative Coatings for Iron and Steel," composed of the following members:

W. A. Aiken.	Patterson-Sargent Company,
The Joseph Dixon Crucible	W. A. Polk.
Company,	W. A. Powers.
Malcolm McNaughton.	A. H. Sabin.
Charles B. Dudley.	G. W. Thompson.
N. F. Harriman.	S. S. Voorhees (<i>Chairman</i>).
International Acheson Gra-	Joseph F. Walker (<i>Secretary</i>).
phite Company,	J. W. Whitehead, Jr.
C. L. Collins.	Max H. Wickhorst.
Robert Job.	The A. Wilhelm Company,
Spencer B. Newberry.	Charles J. Davis.
Charles L. Norton.	Wm. R. Webster.

Since its creation, Committee E (now Committee D-1) has had frequent meetings and reported annually to the Society. Dr. Charles B. Dudley was president of the Society and a member of this committee until the time of his death in 1909. In Dr. Dudley's death, the committee lost a valuable member and individually a much beloved friend.

In 1909, the work of the committee having broadened naturally, its title was changed to "Committee E on Preservative Coatings for Structural Materials."

In 1910, on the reclassification of committees by the Executive Committee of the Society, Committee E became Committee D-1.

Up to 1905, the work of this committee had been most general in character, but in the latter part of that year, it undertook the testing of preservative paints on the Havre de Grace bridge. The 1906 report and those following describe this work in detail.

In 1907, at the request of the Paint Manufacturers' Association, the committee undertook the inspection of a wooden white-paint test fence at Atlantic City. The results of this inspection are given in the 1909 report of the committee and in subsequent reports.

In 1908, a sub-committee on "Linseed Oil" was appointed. Its work is fully described in the 1909 report and in subsequent reports.

In 1909, in collaboration with Committee A-5 on the Corrosion of Iron and Steel, a series of tests was undertaken to determine the influence of pigments on corrosion. This work, started as laboratory work, eventuated in the construction of a steel fence at Atlantic City, which was made possible by the generosity of the Paint Manufacturers' Association. The "water test" is described in a paper by Allerton S. Cushman read in 1908, and the actual results obtained are given in the 1909 report of this committee and in subsequent reports.

In 1910, this committee further developed its organization, creating new sub-committees on "The Definition of Terms used in Paint Specifications," "The Influence of Pigments on Corrosion," "Accelerated Tests," "Varnish," and "Testing White Paints." The work done by these sub-com-

mittees is included in the 1910 report and in subsequent reports.

In 1912, the sub-committee on "Accelerated Tests" was discontinued and a sub-committee on "Paint Vehicles" created. In 1913, the sub-committee on "Testing White Paints" was superseded by the sub-committee on the "Inspection of White-Paint Test Fence at Washington, D. C." In 1913, the following new sub-committees were created: "On Methods of Analysis of Paint Materials," "On Paint Thinners Other than Turpentine," and "On Turpentine."

In 1912, Mr. S. S. Voorhees, who had been chairman of the committee from its inception, resigned the chairmanship, much to the regret of the committee. Mr. P. H. Walker was elected in his place.

The officers and the personnel of Committee D-1 and its sub-committees are as follows:

COMMITTEE D-1 ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

P. H. WALKER, *Chairman.*

G. B. HECKEL, *Vice-Chairman.*

G. W. THOMPSON, *Secretary.*

NON-PRODUCERS (30).

Aiken, W. A.	Millwood, J. P.
Akin, Thomas B.	Ramage, J. C.
Bacon, C. V.	Riddle, G. W.
Boughton, E. W.	Rogers, Allen.
Bureau of Construction and Repair,	Smith, H. E.
U. S. N.,	Smither, F. W.
Material Branch.	Tassin, Wirt.
Cushman, Allerton S.	Van Gundy, C. P.
Force, H. J.	Veitch, F. P.
Gardner, Henry A.	Voorhees, S. S.
Gibboney, James H.	Walker, P. H. (<i>Chairman</i>).
Gill, A. H.	Walker, William H.
Job, Robert.	Westinghouse, Church, Kerr and
Lawrie, J. W.	Company,
Macnichol, Charles.	Cloyd M. Chapman.
McDonnell, M. E.	White, A. H.
McIlhiney, P. C.	Young, J. B.

COMMITTEE D-1 (*Continued*).

PRODUCERS (26).

Bragg, C. T.	Perry, R. S.
Coleman, R. E.	Pickard, Glenn H.
Dixon Crucible Company, M. McNaughton.	Polk, Anderson.
Evans, S. M.	Rigg, G.
Forrest, C. N.	Sabin, A. H.
Heath, A. M.	Schaeffer, J. A.
Heckel, G. B. (<i>Vice-Chairman</i>).	Sherwin-Williams Company, E. C. Holton.
Ingalls, F. P.	Thompson, G. W. (<i>Secretary</i>).
Kohr, D. A.	Toch, Maximilian.
Lane, F. A.	United States Gutta Percha Paint Company,
Lindsay, R. W.	Herbert W. Rice.
Lucas and Company, John, L. P. Nemzek.	White, G. D.
Mackenzie, K. G.	Wilhelm Company, The A., Walter S. Davis.
Neal, C. S.	

SUB-COMMITTEES OF COMMITTEE D-1.

SUB-COMMITTEE I, ADVISORY COMMITTEE.

Walker, P. H. (<i>Chairman</i>).	Gibboney, James H.
Aiken, W. A.	Heckel, G. B.
Dixon Crucible Company, M. McNaughton.	Pickard, Glenn H.
Gardner, Henry A.	Thompson, G. W.
	Voorhees, S. S.

SUB-COMMITTEE II ON INSPECTION OF HAVRE DE GRACE BRIDGE.

Aiken, W. A. (<i>Chairman</i>).	Tassin, Wirt.
Dixon Crucible Company, M. McNaughton.	Thompson, G. W.
Evans, S. M.	Toch, Maximilian.
Gibboney, James H.	Westinghouse, Church, Kerr and Com- pany,
Polk, Anderson.	Cloyd M. Chapman.
Sabin, A. H.	White, G. D.

SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES.

Gardner, Henry A. (<i>Chairman</i>).	Pickard, Glenn N.
Boughton, E. W.	Rogers, Allen.
Kohr, D. A.	Sabin, A. H.
Lindsay, R. W.	Toch, Maximilian.
Lucas and Company, John, L. P. Nemzek.	White, G. D.

COMMITTEE D-1 (*Continued*).

SUB-COMMITTEE IV ON INSPECTION OF STEEL PLATES AT ATLANTIC CITY.

Gardner, Henry A. (<i>Chairman</i>).	Walker, W. H.
Gibboney, James H.	Westinghouse, Church, Kerr and Com-
Neal, C. S.	pany,
Pickard, Glenn H.	Cloyd M. Chapman.
Polk, Anderson.	White, G. D.
Toch, Maximilian.	

SUB-COMMITTEE V ON LINSEED OIL.

Pickard, Glenn H. (<i>Chairman</i>).	Thompson, G. W.
Boughton, E. W.	Voorhees, S. S.
Gill, A. H.	Walker, P. H.
Kohr, D. A.	White, A. H.
Sabin, A. H.	

SUB-COMMITTEE VI ON DEFINITIONS OF TERMS USED IN PAINT SPECIFICATIONS.

Thompson, G. W. (<i>Chairman</i>).	McIlhiney, P. C.
Gibboney, James H.	Walker, P. H.
Heckel, G. B.	White, G. D.
Kohr, D. A.	

SUB-COMMITTEE VII ON INFLUENCE OF PIGMENTS ON CORROSION.

Walker, W. H. (<i>Chairman</i>).	Gardner, Henry A.
Dixon Crucible Company,	Thompson, G. W.
M. McNaughton.	

SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS.

Smither, F. W. (<i>Chairman</i>).	McIlhiney, P. C.
Gibboney, James H.	Thompson, G. W.
Ingalls, F. P.	Voorhees, S. S.

SUB-COMMITTEE IX ON VARNISH.

Voorhees, S. S. (<i>Chairman</i>).	Other members to be appointed.
--------------------------------------	--------------------------------

SUB-COMMITTEE X ON INSPECTION OF THE WHITE-PAINT TEST FENCE AT WASHINGTON, D. C.

Voorhees, S. S. (<i>Chairman</i>).	Macnichol, Charles.
Gardner, Henry A.	Polk, Anderson.
Gibboney, James H.	Rogers, Allen.
Lane, F. A.	Thompson, G. W.

COMMITTEE D-1 (*Continued*).**SUB-COMMITTEE XI ON PAINT THINNERS OTHER THAN TUR-
PENTINE.**

Westinghouse, Church, Kerr and Other members to be appointed.
Company,
Cloyd M. Chapman (*Chairman*).

SUB-COMMITTEE XII ON TURPENTINE.

Veitch, F. P. (*Chairman*). Other members to be appointed.

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REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

Since the Fifth Annual Meeting of the Society, your Committee has held two general meetings and one special meeting. The membership of the committee has been increased from the original 6 to 16 members, and the committee has aimed to include representatives of every class engaged in the commercial production of Preservative Coatings.

The meetings have been confined so far to discussing the best methods of obtaining the desired data for a comprehensive report on this subject, and now, after a year's work, the committee can only submit a tentative report and outline a general scheme of action.

Before beginning this work it was considered necessary to put in concrete form several working headings:

First. Requirements for a satisfactory preservative metal coating.

Second. Methods used and suggested to determine if the preservative coating is efficient.

Third. An index with abstracts if possible, of general and current literature bearing on this subject which has appeared in English, French, German, and American publications.

Fourth. A classified list of all coatings used or suggested for the protection of iron and steel.

The committees on the first two subjects have submitted reports; committees on the last two subjects report progress and request further time for final report.

The report of the committee on requirements for a satisfactory preservative metal coating called out a general discussion and resulted in the following recommendations:

In Preparation of Surface for Painting.—It is considered necessary that surface be free from grease and dirt, and that all detachable mill scale and rust be removed. Material which cannot be removed by hammer and chisel or wire brush, it is thought will not affect the durability of the coating. The use

of the sand blast is recommended, provided it is the opinion of the engineer that the cost is warranted, but it is not considered necessary in all cases.

Application of the Paint.—It is recommended that the successive paint coatings should be as thick as possible, compatible with satisfactory spreading with the brush or machine. The brush marks should flow out. The paint should not contain any large amounts of volatile matter, so as to chill the surface by evaporation.

Drying.—It does not seem possible, without further experimentation, to reach a final conclusion on this point. Whether the paint coats shall dry in six or twenty-four hours is a matter to be determined by the contingencies of the case. In general, it is recommended that as much time as possible be allowed between coats. It is, however, considered practicable to have an efficient metal coating dry in eight hours.

Successive Coatings.—The under coatings must not be softened or acted upon by the subsequent coats of paint.

Protective Power.—This is the keystone of the whole subject. The coating must protect. To accomplish this it is recommended that the coating must have the maximum impermeability to moisture, air, and carbon dioxide. Iron and steel will not rust in dry air or in water free from air and carbon dioxide. The best protection will, therefore, be obtained from the most impervious coating. To this end the pigment should be as finely ground as possible. Finally, it is recommended that the vehicle or pigment, or both, be water repellent. Whether this last characteristic is to be obtained by a pigment such as lamp-black, or by the use of some non-drying oil, must be the subject for further investigation.

Durability.—It is the opinion of the committee that coatings should be efficient under ordinary conditions for at least five (5) years.

The durability measures the life of the coating; it should therefore adhere to the metal through all ranges of contraction and expansion without peeling or cracking.

Neither the pigment nor the vehicle, nor compounds resulting from a reaction of the two, should cause a disintegration of the coating.

It is further recommended that the coating should not be affected by products necessary for the maintenance, equipment, or use of the structure protected. This applies especially to the softening of paint on bridges by burning and lubricating oils from passing trains.

It is finally recommended that the coating be of such a character as to successfully resist the mechanical injury due to sand, cinders, and other material carried by the wind.

Feasibility of Recoating.—There can be no question that a satisfactory coating must permit recoating when needed without additional labor for cleaning and removing old coat.

Cost.—Upon this point it is only necessary to say that the other valuable requirements being obtained, that coating is best which can be furnished and applied at minimum cost.

Tests to Determine Efficiency of Coating.—It is the opinion of your committee that it is useless to prescribe the same tests to all classes of protective coverings. An efficient coating in the dry atmosphere of the Western States may fail to withstand the moist, saline air of the coasts.

A coating which is perfect for structural steel under a static load may fail entirely when subjected to vibratory shock imposed on bridge members and steel cars. In short, tests must be in harmony with conditions imposed in service.

The general cause of failure of coatings to protect is the same as the corrosion of the metal itself—*i. e.*, moist air and carbon dioxide.

Dilute acids, as a rule, have far less action on paint films than alkaline solutions. A paint made from some inert pigment and linseed oil will show no sign of disintegration when immersed for days in a dilute sulphuric acid solution, which would rapidly dissolve the metal it protects, and the same paint would go to pieces in a few hours when exposed to the action of a correspondingly strong solution of ammonia or carbonate or caustic alkalies.

Strong acid solutions rapidly destroy the coating, but it is rare that such conditions exist, and, if necessary, can be met by special requirements.

It is recommended that tests be adapted to the demands of service conditions, and divided into three broad classes:

First. Actual service tests, under normal conditions, applied to structure to be protected.

Second. Accelerated tests, applied to specially prepared surfaces, and subjected to abnormally severe conditions.

Third. Chemical tests to determine the constituents and adulterations of the pigment and vehicle, as far as the knowledge of the subject will admit.

It is undoubtedly true that the first set of tests gives the desired information in a most conclusive manner, but, unfortunately, the truth comes too late to remedy the evil if the protection is insufficient to prevent corrosion.

It is further considered that the function of this committee is not to specify any covering or coverings as protective, but to specify tests which coatings must stand to assure maximum efficiency.

It will therefore be necessary to work along the lines of accelerated and chemical tests, selecting those which harmonize with the results of long time service experiments, and ultimately formulating laboratory tests which can be relied upon to give desired information.

It should, however, be realized that in this work chemical analysis must be used to supplement experience, not to provide it. In general, it is known by previous experiments that certain pigments and oils give durability and protection, while others fail in these essentials; but it will not do to condemn the unknown without the aid of experience.

A review of the suggested accelerated tests shows a variety of methods to impose abnormally severe conditions. These tests have in some cases little connection to service requirements, but it is believed that the results obtained by the methods selected will be in harmony with long time service tests.

It is expected that the following series of experiments can be conducted through the cooperation of railroads and consumers on the one hand, and the manufacturers of standard coatings on the other, the former to provide the structure and labor and the latter the material to be applied.

It is recommended that two coats of the protective coating be applied to parts of full-sized structures, not less than one span of a bridge, one steel freight car, or, in general, one unit of

dimensions corresponding to above. The surface to be prepared and coating to be applied as recommended under those headings.

At the same time, panels of tank steel 20" x 24" x $\frac{1}{4}$ " are prepared and coated in the same manner as the structure and with the same batch of coating. The panels are coated on both sides and on edges of sheet. The work to be done indoors under favorable conditions for drying.

The panels are to have a $\frac{1}{4}$ " hole bored in middle of upper end to facilitate hanging, and are to be stamped with serial number on both sides in upper left-hand corner.

Panels are prepared as above in pairs, one to be exposed "green" and the other to be thoroughly dried under favorable conditions before testing.

The corresponding pair of "green" and dry panels are exposed under the roofs of train-sheds, in round-houses directly over smoke-stacks of engines, from trusses of bridges, on roofs of train-sheds, round-houses, and on roofs adjoining power-house stacks, etc., in tunnels, on docks in salt water and tidal rivers, where they will be immersed twice every twenty-four hours in salt and fresh water in the ebb and flow of tides.

In addition to above series of field panels, special laboratory panels on glass and tank steel are prepared in the same manner as the foregoing. The steel panels are exposed to the action of exhaust steam at a temperature not to exceed 150° F. for twelve hours each day, and ordinary atmospheric air for the remaining twelve hours, the test to be continued for thirty days.

The porosity is determined by noting the absorption of a drop of oil on the coating. If the film is impervious, the drop of oil will run down the panel in a narrow band the width of the original drop, but if the life of the coating has been destroyed the drop of oil will spread out to a more or less greasy blotch, depending on extent of disintegration.

The glass panels are tested for water-repellent properties by treating the dried coating with a few drops of water. Evaporation is prevented by means of a cover-glass, and the coating examined after the water has been in contact for twelve hours.

The capacity of the coating to withstand destructive agencies necessary to equipment and maintenance of structure will require special tests.

For steel cars and bridges the coating on glass is tested with lubricating and burning oils to determine if it is disintegrated. For refrigerating cars it is tested in the same manner with a common salt solution.

A further set of laboratory tests are made by coating saucers of sheet iron 8" diameter 1" deep with two coats of paint. These saucers are filled with ordinary tap water and allowed to evaporate under cover to dryness; the water renewed until definite conclusions can be deduced.

Chemical analyses of the coatings will also be made to determine percentage of pigment, oil, and volatile matter, with composition and quality of each.

The above service and laboratory tests are to be conducted at as widely distant points and under as different conditions as possible. The service tests are to be carefully examined at stated intervals, and the entire series of experiments accurately tabulated for comparison with the long time service tests.

From these data it is expected that laboratory tests can be formulated, which, when met, will insure a satisfactory protective metal coating.

Respectfully submitted,

[Signed]

S. S. VOORHEES, *Chairman*,
 W. A. AIKEN,
 CHAS. B. DUDLEY,
 N. F. HARRIMAN,
 INTERNATIONAL ACHESON GRAPHITE CO.,
 ROBERT JOB,
 JOSEPH DIXON CRUCIBLE CO.,
 SPENCER B. NEWBERRY,
 CHAS. L. NORTON,
 PATTERSON-SARGENT CO.,
 W. A. POWERS,
 A. H. SABIN,
 THE A. WILHELM CO.,
 JOSEPH F. WALKER,
 J. W. WHITEHEAD, JR.,
 MAX H. WICKHORST.

DISCUSSION

S. S. VOORHEES.—I want to emphasize the fact that this report can only be considered a tentative one, outlining in general a scheme of action, which may be followed or may be found to require modification, as there are one or two points which might be changed a little. Mr. Voorhees.

It is not the intention of the Committee to exclude any special paint. We tried to emphasize the fact that any paint which meets the requirements of tests will be satisfactory as a preservative coating. There are certain paints with lead pigments which solidify in the bucket, but if they have valuable features sufficient to counterbalance this objection they will meet requirements.

THE PRESIDENT.—How does the matter stand with regard to the unanimity of the Committee? The President.

MR. VOORHEES.—This report was intended to be accepted *in toto* by the Committee; but there are several minor points which possibly were not—for instance, the five-year clause is one; the question of the solidifying of the paint in the bucket is another; and the extent of cleaning before painting is a third. The character of the tests has also been in some cases thought excessively severe, and in other cases not severe enough; but, as I said, it is simply a tentative report which will be worked on during the next year, and these tests can then be brought down to a more definite basis. Mr. Voorhees.

It would probably be well to strike out the clause "It is also considered objectionable if paints solidify in the buckets," as a certain class of protective paints have that fault—or value, because this solidifying is really a cementing action which is an advantage if it occurs on the metal to be protected; but if the caking occurs in the bucket, that cementing action is lost. That clause will be removed from the present report before it is printed.

THE PRESIDENT.—The principal difficulty as we understand it with red lead is that if perchance more is mixed up at any one time than is spread, it hardens in the buckets, especially if it stands overnight. There are two ways of overcoming The President.

The President. this difficulty: one is to mix frequently and in small amounts; the other is to mix some inert material with the red lead. We have had good success in using a material consisting of pure red lead two parts and kaolin one part, made into a stiff paste with linseed oil. Lamp-black has also been used to overcome this difficulty, and, so far as our knowledge goes, this is unobjectionable.

For the railroads the protection of steel cars is getting to be a very serious matter. Steel cars cost from \$1000 to \$1200 each. How long are they going to last? You will readily see that if corrosion goes on rapidly the loss will be serious. Apparently we are in a dilemma. Proper sizes of wood are becoming more and more difficult to get, and there seems nothing to do but to use the steel car. If the corrosion leads to short life, the losses may be very serious. We have one or two rays of light. An examination was made some time ago of the layer of rust that had formed on the inside of several steel cars of the first lot built for the Pennsylvania Railroad. These cars had no protective coating of any kind on the inside. At the end of two years and three months of service a scale was formed which was detached and sent to the laboratory, with a request to know how much of the original material this scale corresponded to. An analysis of a measured area indicated that one-fiftieth of an inch of the thickness of the original metal had already corroded to form this scale. Some three or four cars gave approximately the same figure. A calculation based on this rate of corrosion indicated that if the car was still available for service when one-half the metal had corroded, the life of a car would be about fourteen years, which is much more gratifying than we feared. The second ray of light which we have is more a hope than something definitely in sight. It is that protective coatings of some kind are now available, or will be devised, which will be sufficient to give a fairly long life to the steel car.

Mr. Sabin.

A. H. SABIN.—It is only fair to say, I think, in reference to this report, that Mr. Aiken, who had in hand the matter of preparing an outline sketch of the method of testing, was unable to act owing to accident. He had a fractured leg and was in the hospital. It occurred at the time when he was collecting material for the report; consequently that part of the report which deals with the tests is quite incomplete, and represents

various views held by various members of the Committee. Mr. Sabia.
I wish to say also that the Insurance Engineering Experiment Station at Boston has been asked to send a man to represent them on this Committee, and we hope that this will be done. What seems to me the most immediately important work of the Committee is that which refers to the collection of papers, or at least of references to papers on the subject, looking up the literature of the matter. Several members of the Committee were asked by the chairman to undertake different parts of this work; but upon investigating the matter somewhat each found that the part assigned to himself was so great that he could not get the time to do it. There is a good deal of material to be gotten together, and it is hoped that in some way in the future something of value may be done in this direction. Until we know what has been done by others, it is certainly premature to go ahead and try to do very much ourselves.

E. PLATT STRATTON.—On behalf of the Society, I think Mr. Stratton.
the thanks of its members are due to the formulators of this Report, and in this connection I recall a time, several years since, when the British Parliament appointed a Special Committee of Experts to collect information and data bearing upon the best anti-corrosives and anti-fouling pigments for use on ships' plating, particularly below the water-line. The outcome of that investigation, which extended over a considerable period, was McGinnis' Compound, generally known among shipping men as one of the best coatings ever invented for use under water; but painters and shipowners have been groping, so to speak, more or less in the dark for years in relation to this very important subject, and I am greatly surprised and much gratified to see this matter so competently dealt with at this time and by a Committee of this Society.

There are, however, in the marine field, two distinct conditions to be dealt with: one is with plating and surfaces below the water-line, where you encounter the troubles and difficulties incident to marine growths and mollusk life which affix themselves with much tenacity to the painted surfaces. All such growth and life when once attached soon develop increased resistance and seriously retard the vessel's progress through the water until removed mechanically, unless the pigment is made to contain elements that are destructive to such growths

Mr. Stratton. and marine life at the start. The second relates to the internal surfaces of metallic ships, where the conditions are different but are no less important in character. All the internal portions of the hulls of vessels liable to be touched or affected by bilge-water and the contaminations of it by the drippings or seepage from cargoes are required to be thoroughly coated with a mixture of Portland or hydraulic cement and sand mixed in about equal parts and laid on with a trowel. Bitumastic cement has been substituted in some instances on account of its reduced weight compared with the former, which is less likely to be affected detrimentally by climatic changes, and is to be regarded as more enduring under all conditions.

About twenty years since naval architects and shipbuilders began the construction of vessels with double bottoms, extending from bilge to bilge all fore and aft over the entire floor of the vessel, such space being subdivided longitudinally at the center by a vertical keelson and transversely into from ten to twenty compartments, the lower or outside plating being well cemented inside to prevent wear and corrosion and to stiffen the plating between the floors. Owing to the inaccessibility of the many parts of the framing existing between the outer and inner bottom, which seldom exceeds thirty-six to forty inches in depth, it was at first thought the material in these spaces would deteriorate very rapidly incident to the emptying and filling of these waterbottoms for ballast with all sorts of impure water, wherever and whenever it might be found necessary to fill them; but experience has shown that "the active agent in the corrosion is the carbonic acid of the atmosphere, which, in the presence of moisture and oxygen, forms compounds with the iron which are unstable and after formation break up, leaving the carbonic acid free to continue its work," and the difficulty is practically overcome by keeping these spaces closed to the air except when such vessels are placed on dry-dock, when the plugs of the limbers are opened and the space between the outer and inner bottoms thoroughly washed out with hose.

The Committee's report certainly gives us all much enlightenment on this subject, which few of us have any time or inclination to exploit.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

On account of the wide difference of conditions and requirements demanded of preservative coatings, Committee E decided to publish in pamphlet form the individual opinions of its members relative to the best methods of testing preservative coatings.

This compilation of the suggested methods is to be distributed among the paint consumers and producers, and engineers, and also through the columns of the engineering and technical press. The methods are published as received.

It is the earnest wish of the Committee that these methods receive the thoughtful criticism of engineers and paint manufacturers, as well as the members of the Committee itself; for it is only by the hearty co-operation of all interested in this important matter, the protection of iron and steel structures, that rational sets of standard requirements can be evolved to meet the many conditions of service.

It is felt that no one set of standard requirements can be imposed on preservative coatings used to protect steel cars, bridge members, structural steel hidden between plaster and expanded metal on one side and brick or stone curtains on the other, and so on through the widely different conditions and requirements demanded in each special case.

In general, however, the paint film which remains most impervious to water, and is satisfactory in other respects, will probably afford the best protection. In a recent paper on "Paints for Protection of Structural Work,"* it was shown that, other things being equal, the finer the particles of the pigment the better the protection, thus emphasizing the necessity for thoroughly impervious coatings.

A satisfactory test to measure this permeability is of the utmost importance. One method suggested among the following schemes dwells at length on this point, and recommends the

* "Result of an Investigation of Paints for Protection of Structural Work," by Robert Job, *Journal of the Franklin Institute*, February, 1904.

use of a film of dextrine beneath the paint coating. On immersion in water, if the paint be pervious the dextrine film will be dissolved and the paint will peel.

It is possible that the suggested electric insulating values of the same film, tested when dry, and after soaking in some electrolyte, as sodium chloride, may afford a measure of the absorption of water.

The coating, however, must be impermeable, not only when first applied, but also after exposure. This brings up the vexed question of accelerated tests. These tests aim to give in a short time results comparable to actual service.

The protection afforded by cement coatings, though of recent introduction and limited application, seems worthy of further investigation. At present this coating requires a moist atmosphere while setting, a condition hard to meet in practice. Its action apparently depends not so much on impenetrability to moisture as on the neutralization of carbon dioxide and acid gases, etc. This action is so different from oil paint films that a comparison of these two types of coatings will be difficult. The Committee hopes that this phase of the question will be thoroughly discussed.

The methods subjoined are the individual schemes proposed by the members of Committee E to test the efficiency of preservative coatings for iron and steel.

Criticism and discussion should be sent to Joseph F. Walker, Bridgeport, Pa., the Secretary of this Committee.

Respectfully submitted,

S. S. VOORHEES, *Chairman.*

METHODS PROPOSED FOR TESTING PRESERVATIVE COATINGS FOR IRON AND STEEL.

W. A. AIKEN.—As Chairman of the Sub-Committee appointed at the last meeting of the Program Committee on "Preservative Coatings for Iron and Steel," I beg to report as follows:

Inquiry from the fifteen other members of Committee "E" for suggestions in the line of experience or theory as to the best methods in their individual opinion, resulted in replies from two-thirds of the members and brought out a very general endorsement of the Chairman's personal views, that "service tests" should be very markedly distinguished from "laboratory tests," and that some arrangement should be made if possible to divide preservative coatings into groups for specific purposes rather than to examine each and every kind with the idea of realizing a panacea.

Examination of the various laboratory tests to which the materials which may be selected should be subjected indicates that those for time of drying, porosity, peeling, cracking, etc., are practically uniform. Many suggestions, more or less elaborate, were offered for what may be designated as "laboratory service tests," namely accelerated tests, bearing somewhat the same relation to actual "field service tests" as does the boiling test for cement to the regular long-time test for that material; very good as a corroborative test, but hardly sufficient of itself for classing the material.

In my opinion too little stress is generally put upon chemical analyses. In all preservative coatings certain essential ingredients should be found, and while certain others may do no harm, certain others may or will. Consequently I should recommend that this matter be taken up in so far as fixing within certain broad limits the percentage of vehicle and pigment, as well as determining the quality of the former, and certain ingredients in the latter, for each class of coating examined.

I should recommend:

1. A series of "field service tests," the more extensive the better, conducted, perhaps, through the co-operation of the rail-

roads and the manufacturers of well-known coatings; the former to furnish the structures to be covered and the labor, the latter the material to be applied under their supervision. A number of bridges, both through and deck, might be painted with different coatings of the same shade and regularly examined. The same thing might be done with a series of trusses in large train sheds; with railroad cars of different classes, such as metal, wooden, coal, refrigerator, etc. In every case the various coatings, such as lead, carbon, graphite, etc., should be applied side by side.

In case the above plan could not be carried out, I should recommend a series of "field service tests" on large metal plates at least 24 inches square and $\frac{3}{8}$ inch thick, to be hung in positions as closely approximating average service conditions as possible; over and under bridges; along sides of trusses; in train sheds; over tracks, etc. These plates should always be in duplicate, the one to be painted as is generally done at construction plants; the other to be properly cleaned and painted in approved manner.

2. A series of "laboratory service tests" on two metal and one glass plate, the two metal plates to be treated as above described for the two field service plates; the glass plate to accentuate, if possible, the necessity of a thoroughly non-absorbent, perfectly clean surface to get best results. The details of these laboratory tests should be so elaborated as to disclose the effects of alternate exposure to moist and dry air, acid and alkali fumes, the sand blast, etc.

3. Chemical determinations of the quality and percentage of vehicle and pigment in each coating subjected to test, as a guide for ascertaining the proper proportions from the results of the "field" and "laboratory" tests.

C. B. DUDLEY.—It is to be confessed, we think, that the test of service is the ultimate test which will prove whether any protective coating is or is not valuable. Experiment as much as we will with exposure tests, and plan them as we will, and continue them as long as we choose, it still remains to actually put the protective material into actual service, and see whether it will give satisfactory results. If a metal structure of any kind is coated with a protective material, and at the end of any designated time it is actually found that the material is not corroded, and is in satisfactory condition, it is evident that such

protective material may be regarded as valuable. If not, the verdict will of course be against it.

But experiments with protective coatings in actual service are extremely difficult to make, and are subject to many vicissitudes. Moreover, they require a long period of time before a conclusion can be reached. If the structure is a permanent one, that is, does not move, the results only apply to the location under which the test is made. If the structure is a movable one, such for example as a steel car, there are very serious difficulties introduced into the test, due to the almost impossibility of watching the car while it is in service, and to the danger of losing track of it before the test is completed. Cars are constantly undergoing repair, a part of which is frequent repainting, and unless some one keeps constant watch over the cars under test, results are frequently lost, due to this cause. Also cars are frequently smashed in wrecks, and in this way tests are lost; so that, taken as a whole, while the test of service is undoubtedly the best and the ultimate one, as already stated, it is only with the greatest possible difficulty that a service test can be obtained.

In view of this difficulty, exposure tests on smaller samples have been proposed. Coat, for example, a number of pieces of metal with the various protective coatings which it is desired to test, and expose them for a period of time. Unfortunately such tests have not a few serious difficulties connected with them. It is undoubted that valuable information can be obtained from exposure tests, but these tests have at least four objections to them: (1) The samples are usually small, and small samples do not quite afford the same opportunity to get the proper amount of coating on them, as if the samples were larger. Moreover, the coating is usually done under more favorable conditions, than apply in actual service. Also, there seems to be a fairly well grounded belief that panel tests, as they are called, are not sufficiently like the actual conditions of service to warrant final conclusions. (2) During exposure tests there is always the uncertainty as to whether something will not happen to the test samples, such for example as the record being lost, or the samples being injured in some way, or somebody not conversant with the conditions interfering with them. We have actually had panel exposure tests within sight of our laboratory, where they were under constant almost daily observation, mixed up,

and some of them lost, due to repairs to buildings, or places where the material was exposed. (3) Exposure tests take a long time, and this long time is not infrequently accompanied with changes in the personnel of those having charge of the test, with a forgetfulness as to exactly what was done with the various samples, and sometimes unfortunately with loss of interest in the test. (4) Probably, however, the most valid criticism of exposure tests on panels or small samples is that the conditions are not those of actual service. The samples are located at one place with a certain exposure. This exposure is not the exposure which structures actually get. Furthermore, the small panels are not under strain, which is characteristic of almost every metal structure in actual service, and whatever deterioration may be due to strains does not appear in the exposure tests. We are not trying to demonstrate or prove that exposure tests are not valuable and do not give some indications at least, which may be of service. But we do believe that in order that exposure tests on panels may be really valuable, they should be much more elaborate, and much more carefully watched, than any exposure tests which we have ever known of heretofore.

In view of the difficulties connected with either service tests or exposure tests of protective coatings, it has occurred to us to attack the problem in a little different way, namely, to ask ourselves what the protective coating is required to exclude from the surface of the metal, and if this can be found, to test protective coatings as to their ability to exclude this objectionable material. It is evident that this brings up the question of the theory of corrosion or rusting of iron and steel, and while it may not be possible at the present time to say the last word on this subject, we cannot help feeling that if a protective coating keeps out water in every form, there will be no corrosion. It is on this thesis that what follows is based. If this is not true, our reasoning and suggestions must be regarded as fallacious. If it is true, we think what follows has some value.

Starting then with the statement that if water can be kept out there will be no corrosion, let us inquire in what forms water may get at the surface. It is obvious that there are two sources from which water may come; first, from the rainfall or other exposure; and second, from condensation of moisture from the atmosphere. The successful protective coating, if we are right,

must exclude from the metal water falling on the surface during the rains or water that condenses when the dew-point is reached.

This brings us to the question whether there is any test which will determine whether water permeates paints or other materials designed to be used as protective coatings. We have spent quite a little time trying to devise a test of this kind. Our first thought was to put on glass or other transparent non-absorbent surface, some substance which would change color when water gets to it, and after the gum holding the material had been dried out thoroughly, coat it with paint or other protective coating, and then put the painted object into water. Experiments with anhydrous sulphate of copper and other materials which change color when water gets to them, proved not very satisfactory. Apparently during the drying of paints of which linseed oil is a constituent, water is formed in the layer itself, due to the chemical action. At least our experiments showed some blueing of the anhydrous sulphate of copper, even before the specimen had been put in water. The most successful results which we have obtained in our attempt to test whether water permeates a layer of paint or other protective coating, have been by using a water solution of dextrine. Dextrine can be completely dissolved in water, so as to give a uniform smooth layer, such as appears for example on the back of a postage stamp. This layer when applied moderately thick has a little tendency to peel when drying. The addition of a little ordinary alcohol seems to overcome this tendency. A good working formula is 20 grammes of dextrine, 40 cubic centimeters of water, and 30 cubic centimeters of alcohol. In spreading, it is desirable to have the layer as thin as convenient, and to allow it to dry out without heat for ten to twenty minutes. In heating it is not desirable to exceed 150° F. Such material applied to a portion of a piece of glass for example, and then dried out thoroughly, using heat if necessary, gives a thin layer on the surface. If now the whole piece of glass is coated with a paint or protective coating, and it is allowed to dry, and followed by another or a third coat if desired, the whole being allowed to dry and harden for a period of time, we have as the result an object which, when plunged in water, gives apparently a very satisfactory test as to whether water gets through the layer. We have made a number of such tests, and have found to our astonishment that

almost no paint containing linseed oil as a constituent, is impervious to water. It is obvious when the coated glass is put into water and allowed to stand, perhaps over night, if water gets through the layer, it will soften the dextrine and cause the material over it to peel. Moreover, a layer of dextrine prepared as above, is almost completely transparent and invisible on the glass after it is dried. But when water gets to it, there is a little change in appearance, making the spot quite visible. This change in appearance and peeling of the coat of paint is the common result with most paints which we have tried, which contain linseed oil. It has been our custom to put the dextrine on in the form of a spot about $1\frac{1}{2}$ inches in diameter, and we have not a few painted glasses where the dextrine covered spot is bare, the rest of the glass still retaining the paint which was put on. The test is new and we have not yet had opportunity to exploit it as far as we would like. It is obvious the glass must be free from grease when coated with dextrine.

There are still some uncertainties in the tests. For example, it is well known that a linseed oil paint does not reach its final state of oxidation, or the change which we call drying, for quite a period of time. We have not yet made any tests, where the paint layer was allowed to harden for more than ten days or two weeks. It is possible that a longer time before the paint was tested would prove advantageous, and there is considerable indication that such would be the case. There are indications still further that the presence of pigment very greatly helps the linseed oil to resist the penetration of water, and also a good deal of evidence that the fineness of the pigment is a most important element in the water resistance of the layer. Furthermore, the nature of the pigment seems to be an element likewise in the problem.

The query may arise, why is it or how it happens that a layer of paint made with linseed oil should allow water to get through it?

It seems almost incredible that an oily substance spread out in a thin layer should not so completely repel water that there would be no permeation of the layer. But it must be remembered that dried linseed oil is no longer an oil. The mass of dried linseed oil, if we may trust Mulder's researches, is a tough leathery sort of material, which does not leave an oily stain when touched, and which is changed chemically from being an oil into a material which Mulder calls "Linoxyn." During the

drying or the change of the oil to linoxyn, there seems little doubt but that oxygen is absorbed and carbonic acid at least is given off; but if carbonic acid is given off as fast as it is formed, it must escape, and it must escape not only from the outer surface of the layer of paint, but also deeper down in the layer, and it is believed that this escape of the carbonic acid, it being a gas, leaves apertures in the dried layer, through which apertures the water passes when the material is tested, as has already been described. Whatever the philosophic explanation of the porosity of the layer of dried linseed oil paint may be, if our experiments are to be trusted, this porosity is a universal characteristic at least of the layer two weeks old.

It would perhaps be too strong a statement to make without limitation, but we cannot help feeling that our experiments seem to indicate that it is going to be difficult, not to say impossible, to make a perfectly water-resistant protective coating out of a material which consists largely of linseed oil. Substances brought forward as protective coatings which dry by evaporation of the solvent, seem to offer much more prospect of success.

It will hardly be fitting at this time, and in this state of our knowledge of the case, to discuss methods which have been suggested to make the layer of paint impervious to water, such, for example, as mixing with the paint an oil which does not undergo chemical change, but remains an oil in the paint layer, the philosophy being that finely divided pellicles of oil would help to repel moisture; also the dusting over the paint just before it gets completely dry, with finely divided pigment, the idea being to fill in all the little pores or interstices which may be left as the result of the operation of drying, or again the subjecting the painted object to a temperature sufficiently to soften the layer, so that the pores, if any there be, would close up as is done in the well-known operation of enamelling. Our thought in this whole matter has been, if we had some test that was completely reliable, to tell whether any material suggested or offered as a protective coating did actually prevent water from reaching the metal layer underneath, it would be a decided step forward in our study of this interesting problem. It is not hoped or expected that the test suggested above will be final. At present it is the best test that we know how to suggest, and it is hoped that further study along this line, by anyone interested, may

result in either improvements in the test suggested, or the development of something better. Finally it is not hoped or expected that a test which enables us to say that any given protective coating actually prevents water from reaching the material, will enable us to say that such protective coating will be satisfactory in service. Of course exposure tests to get the influence of the sun, and to study durability under actual conditions, are still essential. But it is believed that no protective coating will be a satisfactory one, that does not keep out water, and that every successful protective coating must pass the test suggested, or some modification of it. If our reasoning is correct, we have got to begin at this point; and if our experiments are to be trusted, the protective coatings at present available are not as valuable as we have been hoping.

N. F. HARRIMAN.—The practice of the Union Pacific Laboratory to determine the relative value of paints, is to make the following tests:

Chemical Analysis.—The paint is subjected to the usual analysis for this material, special attention being given to the nature and fineness of the pigment, the presence of dryers and the purity of the oil. If the results of the chemical examination are such as to justify it, the paint is subjected to service test.

Service Tests.—We use pieces of sheet iron, about twelve inches square, for the exposure test, one-third of the sheet being in the condition just as it came from the mill, *i. e.*, covered with scale; one-third is sand-blasted, and one-third has the scale removed with acid. These sheets are coated with one, two and three coats, respectively, of each paint. During application of the paint, attention is given to the spreading and covering power, and the time required for drying is noted. About twenty-four hours is generally allowed between successive coats.

After noting carefully the physical characteristics of the paint on application, these sheets are hung up in places where it is known that the conditions are especially severe, such as in round-houses, under viaducts, etc., in order to get an accelerated test, under conditions to which the paint will be subjected in actual service on such structures.

Paints to be used on wooden structures are generally exposed merely to the weather. In all cases, the sheets are examined at regular intervals and their condition noted. In all of

our paint tests, an effort is made to subject the paint to the same kind of conditions to which it will be subjected in actual service.

INTERNATIONAL ACHESON GRAPHITE COMPANY.—We have recently made, and almost completed, a series of 10 tests on about 40 paints; 4 of these tests being in the nature of long-time durability tests, the other 6 rapid chemical or physical tests. All tests were made in duplicate on surfaces painted with two coats.

The long-time tests included (1) an exposure test, painted strips of sheet iron being placed on the roof of one of the factory buildings; (2) an evaporation test, in which shallow iron pans were partly filled with tap water and allowed to stand uncovered, the loss due to evaporation being made up from time to time; (3) a weak acid test, which was much the same as that last mentioned, except that a 1 per cent sulphuric acid solution was used instead of water; (4) a brine test, a strong brine solution being allowed to drip slowly upon painted sheet-iron strips arranged one above the other so as to drip from the lower end of one strip on to the upper end of the strip next below.

The accelerated tests consisted in treating the coating (1) with a 2 per cent solution of sodium hypochlorite;* (2) with nitric acid (specific gravity 1.2); (3) with "red" lubricating oil; in testing permeability and water-repellant properties by placing a few drops of water on the coatings and noting the action and, finally, in testing the hardness of a coating and in making a qualitative analysis of the paint.

As a result of these tests, and of the discussion at the recent meeting of the Committee in Washington, we should recommend that a test for porosity of coatings be included, and we are making a number of experiments for the purpose of devising such a test. The method which at present seems most hopeful is that of applying the paints to polished marble slabs, immersing these in dilute hydrochloric acid for a certain length of time and noting any action on the marble after removing the coating, shown either, qualitatively, by a roughening of the polished surfaces or, quantitatively, by the loss of weight of the slabs.

As regards the tests proposed by Mr. Sabin for determining the insulating power and porosity of a coating by subjecting it to a high voltage both when dry and after soaking in water, it

* This test was extremely severe, but was introduced as a help in meeting a demand for a good protective coating within bleaching powder chambers.

seems to us that the nature of the pigment used, as well as that of the vehicle, would so largely influence such tests as to make comparative porosity determinations impracticable.

The service tests proposed in the Committee's last report seem to us as thorough as could be desired.

ROBERT JOB.—In making comparisons with service value results we have found the plan of alternate wet and dry exposure gives rather better data than any other test. The test can be applied with sheet-iron saucers and ordinary evaporation as given in the report of Committee E for 1903, or sheet-iron panels, say 5 by 8 inches, may be coated with the material and after thorough drying, immersed each night in water slightly acid, to simulate conditions of coal-car trucks, and exposed to the sun during each day. The paints which have given best service with us have stood this test well. In addition to this we have found that the test of the dried coating with water often gives valuable indications.

By taking a given composition,—say pure linseed oil and inert material,—one can determine by simple tests, such as fineness, etc., whether good results may be expected in service, and a definite standard of quality can be readily maintained. But in the general testing of paints of other composition we at present feel obliged to depend largely upon the longer time exposure tests such as those mentioned above.

Our usual plan is to coat sheet-iron and glass slips, to test these as above described, and at the same time to determine the composition for general information.

JOSEPH DIXON CRUCIBLE COMPANY, REPRESENTED BY MALCOLM McNAUGHTON.—In outlining a test scheme for protective paints, the following points are to be considered: cost, application, drying, adhesion, elasticity, porosity, resistance to mechanical injury, permanency.

1. *Cost.* This point may or may not be included in a scheme for testing paints. It is properly included when the test is made by the person who is directly interested in the economic side of the question, and may properly be left out by him who has to determine only the value of the paint as a protective coating.

2. *Application.* This bears on the facility with which the coat may be applied, whether it may be properly applied over other and different coatings, whether it may be applied at all

ordinary temperatures, and whether or not any special treatment of the surfaces is required. Knowledge on these points is only to be had by actual trials.

3. *Drying.* Continued observation during an actual trial will give all the information necessary on this point. But it is necessary that observations be made up to the time that the paints are actually hard and dry, because it may happen that one paint may begin to dry on the outside more rapidly than another which may finally pass it and become dry first.

4. *Adhesion.* This is a most important point, it being self-evident that any paint to protect must stay in place. Relative adhesion, when decidedly unlike, may be detected when the paints are fresh by simply peeling off at the point of a chisel. But adhesion must persist throughout the life of the paint, so that it becomes necessary to test the paint films after having given them somewhat the effect of age. Probably as fair a way as any, to secure this effect, is to subject plates of painted iron or tin to repeated alternations of heat and moisture. Tests for adhesion should be made before any others, as a paint coat which lacks this quality, when new, should be immediately condemned.

5. *Elasticity.* This quality enables a paint film to accommodate itself to its base during changes as a result of variations of temperature or form. When we consider the great difference in the coefficient of expansion between the metals and oils, we see that, unless there is a certain degree of elasticity, rupture of the paint film must occur. Films of the paint, detached from their support, are best for determining relative elasticity. The simple test of bending is enough to give information where the difference in elasticity is enough to be of importance.

6. *Porosity.* Since iron does not rust except in the presence of moisture, it is important that the protecting film of paint should be non-porous in the highest degree, without the sacrifice of other desirable qualities. This is a test which should be applied when the paint is in its most perfect condition as a protecting film. It is not correct to test by repeated evaporations of water in a painted dish, because the deterioration of the paint by these repeated evaporations is also involved. The method in which postage stamps painted on glass, covered with a couple of coats of paint, and when dry, immersed in water, seems good. This may not be exactly correct in its technical

aspect, but should give approximately correct results when made for comparative purposes.

7. *Resistance to Mechanical Injury.* Tests to determine this need be made only in special instances where conditions are such that protective coverings may fail from this cause. Where such a test is advisable, it is easily made by allowing a stream of sharp sand to flow over the painted surfaces from a hopper, the sand being returned from time to time. The test is easily made more or less severe by varying the height of fall and angle at which the stream strikes the plate.

8. *Permanency.* Protective coatings may be assured as quickly reaching their condition of greatest efficiency. We may consider that when a paint has become what we call dry, it has reached that condition. From that point of greatest efficiency there is a gradual, more or less rapid progression toward ultimate failure. The paint in which this progression is slowest is to be taken as the most permanent. The value of this function must be determined entirely separate from the determinations of the other qualities, and the test should be so conducted as to bring about a slow change, rather than to destroy. The test should be made with especial reference to the conditions under which the paint is to be used. The test should be made with paint films which have been detached from their support. They should be of sufficient thickness, not less than two coats, and probably three would be better. They may be prepared on thin zinc plates, the zinc being dissolved off by dilute sulphuric acid, or they may be prepared on cardboard covered with a paste of dextrine. When dry the whole is immersed in water and the support soaked until it may be separated from the film. Films of various paints to be compared are subjected to the same set of conditions and their relative action observed.

It is much easier to detect changes in films separated in this way than when attached to their supports.

The foregoing tests, while simple, and probably capable of much improvement, are sufficient to give considerable information when made carefully for comparative purposes, yet at the same time they do not give exact values. Under any one test in question, it will be easy to show that one paint is better than another, but not so easy to show just how much better. Judgment in this matter can only come with experience. It is to be

supposed that any test of paints is for the purpose of selecting the one most suitable for some set of actual conditions, and that these actual conditions indicate the relative importance of the tests to be made.

The rate of drying, resistance to mechanical injury, porosity, adhesion, etc., may each in turn be the feature of greatest importance. It would certainly be an absurdity to lay much stress on relative porosity of a coating which is to be applied to bridges in Arizona, or to pay much attention to the matter of elasticity in a paint for ironwork in a damp subcellar.

Unfortunately, no paint has yet been discovered which possesses preeminently all the qualities needed for iron and steel protection, so it becomes necessary for us, if we hope to get best results, to determine in some way what particular product is at least as good as any other for the case in hand. Our tests may not always indicate the very best, but they will undoubtedly put aside the very worst, and this result alone will be a great gain. It seems to be entirely within the scope of this committee, in addition to suggesting methods of making tests, to suggest also a scheme for combining the values obtained by such tests, into an equation, the solution of which will give relative values in particular cases. For instance, the efficiency of a coating may be represented by an equation where one side consists of the sum of the values for the various functions previously determined by experiment, each multiplied by a factor which represents its particular importance in any specified case. Thus in different cases we may take the factors as follows:

Cost.....	1	Cost.....	1	Cost.....	1
Application.....	1	Application.....	1	Application.....	1
Drying.....	4	Drying.....	1	Drying.....	1
Adhesion.....	2	Adhesion.....	1	Adhesion.....	1
Elasticity.....	1	Elasticity.....	1	Elasticity.....	1
Porosity.....	2	Porosity.....	1	Porosity.....	10
Resistance to Me-		Resistance to Me-		Resistance to Me-	
chanical Injury.	3	chanical Injury.	1	chanical Injury.	1
Permanency.....	2	Permanency.....	6	Permanency.....	1

The first set might be used in testing paints for steel cars, the second for highway bridges, and the third for ironwork in locations subjected to steam and acid vapors. Such a scheme will have its limitations and variations due to the personal equation

of the man operating it, but eventually there would come a certain degree of standardization. These suggestions are presented with the idea of showing the advisability of a scheme which will necessitate the consideration of all the points involved.

With regard to time tests, not much need be said except that the pieces to be exposed should have at least 2 square feet of area on each side, and should have two coats, the second applied only when the first is dry. The second coat should be dry before exposure occurs, and the exposure should be average conditions it is desired to protect against. The test piece should consist of vertical and horizontal parts, the latter to serve as a resting place for water, cinders, dust, etc. Where such pieces have been examined from time to time, such places should be covered by paint to prevent extension of corrosion from the damaged surfaces. This patching-up paint should be of a different color than the paint which is being tested, to avoid any confusion.

S. B. NEWBERRY.—It is difficult for me to suggest a scheme for testing Portland cement as a protective coating for iron and steel, since the methods of using it for this purpose have not yet been developed. After carefully reading the outline of tests suggested by Committee E, however, I think there is no reason why cement should not be submitted to the same tests as other paints, so far as these are found to be applicable. Cement coatings should, however, be kept in *moist air* at least 24 hours after being applied. Whether this will prove practicable on a working scale must be determined by experience.

For these experiments cement in extremely fine state of division will be necessary. We have facilities for furnishing such cement, prepared from our regular product by air separation, and could ship a barrel or so for experiment at any time. The cement should be mixed with water to about the consistency of ordinary oil paint, and kept thoroughly stirred while being applied.

I would suggest also experiments with cement with the addition of calcium chloride to the amount of 5 and 10 per cent of the weight of the cement, having found by experiment that this aids greatly in producing a thorough set of the cement before drying takes place.

PATTERSON-SARGENT COMPANY, REPRESENTED BY W. A. POLK.—“In experimental science, two methods of progress are observed; first, in actual practice certain methods are adopted because they are found to be the most advantageous and useful, though we cannot explain why it is so—*i. e.*, practice outstrips theory. Again, as a result of experimental investigation, certain facts are discovered which explain why the practical methods just alluded to are the best, and this in turn suggests further improvements in our practice—*i. e.*, theory outstrips practice and enlarges its domain. This is what the laboratory does for the paint business.”

The writer has had some experience in observing tests of paint made by covering plates of sheet iron and exposing these in places where the conditions were particularly severe. For instance, in making a test of paint for the protection of the steel on the interior of a train shed, such painted plates would be hung in positions where they would receive not only the gases and fumes from the locomotives, but they would be hung directly over the smokestacks in such a way that the blast of cinders and the direct contact of sulphurous gases would affect the painted surface to a degree which would seldom occur in practice.

The adherents of this system of making tests naturally ask, is not the paint subjected to the same conditions and is it not a truly comparative test? Such a test would be truly comparative, but that is not what is desired, if I understand the scope of the subject in hand. Surely, if a train shed is to be protected from gases, it is to be protected as a whole, and no particular spot is to be especially singled out for protection. Whilst such places are to be found in all train sheds, they must have special treatment. In other words, the diagnosis of each case must be based on the conditions of that particular structure.

In respect to the preservation of bridges, many tests have been made in which none of the coatings were applied directly to the surface of the bridge in question; but plates were painted and suspended beneath the structure. The same objection applies to this sort of test as to the one referred to above. On a railroad an entire bridge should be painted with a coating of one character, whilst half a dozen others on the same division, subject to the same conditions, should each be painted with a coating of a different character. Practical results could be obtained

in this way which would be far more instructive than those obtained from a number of plates hung under the same bridge. The question may be asked: Is it possible to find two bridges alike in respect to the condition of the surface to be painted? Theoretically no, but practically any two surfaces may be made essentially identical by thorough cleaning.

To go back four years, to the tests made on the One Hundred and Fifty-fifth street viaduct over the Manhattan Elevated Railroad, under the supervision of the Department of Public Works, for the purpose of determining the relative merits of a number of protective coatings, an expense of several thousand dollars was incurred in cleaning the surface of the bridge by means of the sand-blast. In this case a practical as well as a theoretical demonstration was made of the possibility of cleaning a surface perfectly. The surfaces to be painted were of sufficient size to ensure results of practical value. These results are matters of record, but the point that the writer would especially accentuate is that this test was made in a thoroughly practical manner.

The preservation of steel cars is a question requiring careful study. The preparation of the cars for painting is obviously of prime importance. An experience will serve to show to what extent this point should be considered. In making an observation recently the writer noticed that the plates of a new steel car were covered with oil which had been used on the rivet holes. This oil had spread over the surface of the car in large spots. The writer instructed the painters to remove the grease entirely from the surface, but before these instructions had been given the men had painted a part of the car without removing the grease. On the following day, after the entire car had been painted, it was found that the coating was entirely dry except on the first section from which the grease had not been removed. The paint on this section was perfectly wet; that is to say, it was in the same condition as when first applied. In order to expedite the completion of the car, the men were instructed to wipe off both the wet paint and the grease which had caused the trouble. Where the grease remained, both it and the paint could be wiped off, but from contiguous spots where no grease existed the paint was hard and clung so firmly to the steel surface that it was removed with difficulty by the use of a knife.

Another matter of importance in this connection is the removal of mill-scale and rust. The painting of steel cars offers an opportunity of painting under precisely the same conditions if each car be cleaned alike. Naturally the conditions of exposure vary to some extent, but a record could be kept of certain cars and by inspection from time to time instructive results might be obtained. Cars might be chosen which remain continually on the same railroad, for example, cars carrying coal from the mines to tidewater.

Much might be said concerning tests of protective coatings in respect to ships, but I believe this should be regarded as a distinct field and receive separate treatment.

It is frequently impossible to get the best results from the use of a good protective coating, owing to the lack of practical knowledge of painting by the inspector, both in the shop and field work. If a good job of painting is desired, a good paint must be used, but *good paint will not apply itself*. The best paint ever made will blister, peel, flake and give all sorts of trouble if it is not properly applied. The principal causes of trouble are as follows:

1. *Moisture*. Paint will blister and peel, if the surface to be painted contains moisture, for paint will not adhere to a damp surface. For this reason, paint should never be applied in wet or freezing weather.

2. *Thickness of Coat*. Paint will blister and peel if it is applied too thickly. *Rub it out well*. A thin coat of paint will wear better than a thick one. There is perhaps more trouble from this cause than any other. A good brush must be used to rub paint properly.

3. *Bad Primer*. Paint will blister and peel, if the primer is not right. Many seem to think that anything is good enough for a primer. This is a serious mistake, as the primer is the foundation, and, therefore, the most important coat. A surface well primed almost always means a surface well painted. A different shade from the finishing coat should be used for the primer, so as to aid inspection.

4. *Time for Hardening*. Give each coat time to harden before applying the next, as a second coat will not adhere to the priming coat if the priming coat is not thoroughly dry when the second or finishing coat is applied.

5. *Workmanship.* Employ skilled labor in making tests, as it requires experience and good judgment to apply paint right. The inspector should be instructed in certain everyday practical points to be observed in the application of any protective coating; for example, that the surface is free from grease; that the paint is thoroughly rubbed out, and not flowed on like whitewash; that a stiff round brush is used, which carries more paint and enables it to be well brushed out. Careful inspection will always assist the engineer in securing a satisfactory protective coating.

In designing a series of tests to determine the efficiency of protective coatings it should be clearly understood for what purpose the paint is intended, and such tests should be applied as will determine its fitness for the special purpose in view. Should our Committee succeed in this respect its work will be of great value, but, to quote the opinion of a well-known chemist, "It would be unfortunate if it narrows itself down to the idea that a few laboratory tests can be applied to any paint, and its fitness for any purpose thus determined. The rational solution of the paint, or, rather, the painting problem, seems to be to have the case prescribed for by some one familiar with protective materials, and the question of whether the paint shall be thin or thick, or what shall be the composition thereof, will have to depend upon the conditions to be met. Familiarity with the various paints offered for sale is perhaps of more value than a series of tests in a small way, and the conditions of service are now pretty well known, so that a knowledge of the composition of the material offered is nearly always sufficient criteria upon which to base an intelligent opinion."

A. H. SABIN.—Comparative tests for protective coatings for structural steel must be time-tests under such conditions as are to be met in actual practice. I do not think that any so-called accelerated tests which have yet been proposed are of any value, but on the contrary are misleading. The fact is that the intelligent use of such material requires that for any given use a coating shall be selected which is especially appropriate for that particular kind of service; and that it shall be used in such a way as to prolong its efficiency as much as possible. On the other hand, the person who plans for an accelerated test devises conditions which will destroy the coating as rapidly as possible without entirely obliterating the differences between the various

preparations used. These conditions must be not only abnormal, but unnatural; and the end sought is exactly the opposite of that desired in practice. Even when the action of a single agent is concerned, it is impossible to prove that an increase of intensity is similar to a prolongation of action; in fact, a little reflection shows this to be in its nature improbable. For example, let us consider the effect of temperature; it has been proposed to learn this by exposing the object for a short time to an increased heat. But at once we encounter difficulties; thus, wooden beams exist in a roof a thousand years old and wood is found in Egyptian tombs two or three thousand years old; but if we heat a piece of wood to 400° F. for a short time it is destroyed. Again, some varnishes or paints are by a certain rather high temperature fused into an enamel, and their durability and protective effect greatly increased. Thus it appears that the effect of heat is uncertain and incalculable. The same is known to be true of some chemical agents, and is perhaps true of all. I conclude, then, from these and other reasons (as well as from experience and observation), that accelerated tests are misleading and irrational.

Certain so-called exposure tests are also of this nature. There are many places (such as the smoke-jacks in a round-house) where experience has shown that paint does not afford any protection; obviously these are not places to put paint. It is a waste of time and money to paint such places; it is as useless to expect paint to be of value as it would be to expect it to increase the strength of a bar of metal. No exposure test is of value which is not conducted under as favorable conditions, and as nearly as possible the same conditions, as those which will be met in practice.

These imply that the paint shall be carefully and skilfully applied to a steel surface. The question now arises, shall this surface be specially cleaned, as by pickling or sand-blasting, or shall it be covered with mill-scale, or with a more or less thick coating of rust? Some users of paint say that as it is impossible for them to clean the metal thoroughly, and as they wish to know what is the best paint for their conditions, they want a test on rusty iron; they are looking for a coating which will arrest or retard rust which is already well under way. This does not to me seem the proper function of paint; but we may let

that pass; if the consumer thinks that is what he wants, and the supply man wants the consumer's money, it is probable that they will try to find some common ground; still, I do not conceive it to be the business of this Society to encourage unreasonable and unjustifiable expectations. But leaving that view of the matter out, what will be the result of such tests? It was said by Smeaton, over a hundred years ago, that if rust had started it was impossible to stop it by paint; nearly every expert since his time has repeated this conclusion; and while some engineers will tell of great success in using paint on rusty iron, I never saw a paint manufacturer who believed in it. The most immediate difficulty is the lack of uniformity in results. It is impossible to get two rusty plates which are alike; and not only are there different thicknesses, but different kinds of oxides, holding varying amounts of moisture. The steel itself is not a homogeneous substance, and the differences in its composition are emphasized and made more important by the varying conditions of rusting. If we would gain uniformity it is only by avoidance of rust. This is the most immediate argument against the use of rusty plates. I do not believe the experiments repeated with the same paints on rusty plates will ever give similar results; and I think it is common experience that irrational results of tests are either traceable to or are attributed to differences in the surfaces to which the paints were applied, more often than to any or all other causes. I know that so far as I am concerned, I would never take any interest or attach the slightest importance, to paint tests made on rusty surfaces.

If the tests are to be made on clean plates, they may be cleaned either by the sand-blast or by pickling. The former is a very perfect method, but not always available. Pickling with acid is easily done and requires no special apparatus. If the plates are greasy, they should first be put in a hot 10 per cent solution of caustic soda for a few minutes, then well rinsed with hot water; they are then put into a hot solution of sulphuric acid, the usual strength of which is 10 per cent, but may be as high as 25 or 28 per cent. They are left in this until a clean surface is obtained; this may take from five minutes to an hour or more, according to the condition of the acid bath. They are then washed; the common way is to dip them in hot (preferably boiling) water, then in hot 10 per cent carbonate of soda solu-

tion, then again in boiling water (if this is used for many plates a second rinsing in hot water is desirable), then they are dried in a hot oven. Or they may be taken from the acid and plunged at once into boiling milk of lime, and after a few minutes rinsed in hot lime-water, then dried in an oven, and when dry thoroughly brushed to remove the adherent lime. Or, they may be taken from the acid and washed by a jet of water impinging on them with a velocity due to a pressure of at least a hundred pounds per square inch, and then dried in the oven. Having cleaned them, the utmost care must be taken to keep them clean. They should be handled only by their edges, and kept in a box the bottom of which is thickly covered with dry caustic lime, until the paint is quite ready for application, when the first coat must be applied as rapidly as possible, in a dry warm room, to both sides of the plate.

Both the size and thickness of the plate should be considerable. My own tests have been made on 12 by 20 inch plates, $\frac{1}{8}$ inch thick; larger ones would be better. They should be of that class of steel plates known as "pickled and cold-rolled," having been pickled at the mills before the final rolling. Care should be taken to have all the plates from the same lot of steel; even then I do not believe they will all be alike. Each plate should have a hole, about $\frac{3}{8}$ or $\frac{1}{2}$ inch, about an inch from the middle of each end, to hang them by; and a number should be stamped on the plate in some convenient place; the center is as good as any. In addition to the stamped number I have always marked the plate on the edge with a series of saw-cuts, thus, plate 176 would have, first, a single cut, then a clear space of an inch (to the right), then seven cuts, then a clear space, then six cuts. These marks can never be obliterated by rust, and are easily found. All this, of course, would be done before pickling, so as to avoid fouling and rusting the plate.

Paint is always thin on the edge of a plate; and the border of a plate, for at least an inch back from the edge, should not be counted in a paint test; but as rust always spreads from the edge in a prolonged exposure, I would apply a striping coat along this margin between the first and second coats and also another after the second coat; and even then I think it would be the best way to have each plate set in a wooden frame, such as are put on slates for school-children, after the painting is com-

pleted. This is to provide against accidents; an accident destroys the value of all previous work.

Each coat should be as thick as will lie evenly, and should be given time to dry before another coat is applied; I should say a month in a warm dry room; while drying, the plate should be hung away from the wall; I usually hang them from the ceiling.

At certain designated spots, say two inches from the edge and opposite the middle of each longer edge, also halfway from that point to each end (six spots in all) the thickness of each plate should be measured by a micrometer caliper immediately before painting, and again after painting and drying before exposure; this shows the thickness of the film. At stated intervals this measurement should be repeated. It appears to me that it might prove a valuable plan to have a duplicate set of plates, and from time to time determine the insulating power of the coating; not that I would care for the absolute insulating power, for some paints naturally are better conductors than others, but most paints are insulators, and the resistance to current indicates in such cases a non-porous coating; and if they become porous by exposure or age the electrical test should show it. These tests would naturally be made successively on different parts of the same plate, not rupturing the coating at any one time except in one place. I do not think that such an experiment has ever been made; but if it would show the porosity of the coating at different periods it would be of the highest interest.

Not less than two coats of paint should ever be used in practice, because all paint is porous, and we overcome this defect in a measure by successive coats; hence I would value tests made with two or more coats; but in my own practice I find it instructive to expose a single coat; this is, however, done by me in testing varnishes rather than protective coatings in general. I find that an exposure of a single coat for a period of three to six months results in a sensible deterioration; these exposures are made on the south wall or the roof, where the conditions are very severe. I have never tried any coating which will not begin to show deterioration in six months; and it may be that tests of this kind will prove of some value. Any such tests should be made with as much care and concurrently with other long-time tests of the same material used in two or more coats.

As to the places where exposures are to be made, it seems to

me that a series of plates should be exposed on the roof of a building, rigidly attached to a framework, so that the sun, wind and rain can get at all equally, within two or three hundred feet of the shore of a body of sea-water; another set similarly exposed in the country, away from the coast; perhaps a set near the shore of one of the great lakes; and a set should be placed on the roof of a not very high building in or adjacent to a railroad yard, where it will receive the gases from engines. I would not make exposures on the tops of railway bridges, because no two plates can possibly have the same exposure; and the same is true of train sheds, unless the cases containing the frames can be so placed that it seems certain the exposures will be uniform.

G. W. THOMPSON.—Protective coatings should be selected or designed by the architect or engineer according to the conditions to which the coating is to be subjected, and with such knowledge of the qualities of the coating as will enable him to satisfy himself intelligently as to the merits of the coat to be applied.

A protective coating protects in proportion to its impermeability, its hardness and its elasticity. It should be as impermeable as possible to moisture, which is the principal factor in the corrosion of iron. Hardness and elasticity are, to a certain extent, the reverse of each other—the hard paint being usually inelastic and the soft paint elastic. Generally speaking, a paint should have the maximum hardness consistent with the elasticity required by the conditions to which it is subjected. With extreme variations of temperature, such as occur on bridges, great elasticity is required; while, with the steel framing of buildings and underground work subjected to little variation in temperature, elasticity can safely be sacrificed to hardness. Tests on permeability, hardness and elasticity of protective coatings should be applied wherever practicable.

Generally speaking, the impermeability of a coating is proportional to its thickness. The architect or engineer should, therefore, know the approximate thickness of a coating or coatings when applied. The surface covered is inversely proportional in area to the thickness of the coat left on the surface. All protective coatings should be brushed out as thoroughly as possible, as, otherwise, there will be sagging and settling out of pigment, if pigment is present, this settling being sometimes

away from the surface painted, as on the under side of I beams. The architect and engineer, by knowing the spreading power, and from this the average thickness of the coat applied, can judge whether the additional cost in labor in the application of extra coats is warranted in the case of protective coatings of high spreading power; they should continually bear in mind that high spreading capacity is not in itself a good quality in protective coatings for the reason given—to wit, that a paint having a high spreading capacity gives a comparatively thin coat on each application. One gallon of paint spread over a perfectly smooth surface so that it covers 800 square feet of surface would have a thickness of 1-500 inch. In the case of a protective coating that is spread twice as far as this in each coat, the number of coats should be doubled to obtain equal protective power, provided other things are equal.

The architect or engineer should also know what proportion of the paint is volatile, as that adds nothing to the thickness of the protective coating and, in this particular, nothing to its protective value.

If the protective coating contains solid pigments—if it is a paint, in other words—the architect or engineer should know in what proportion the pigment is present both by weight and by volume. It may be considered as well established that in linseed-oil paints the greater the per cent by volume of pigment, the greater will be the impermeability of the protective coating; to this extent, at least, the pigment protects the vehicle.

It should be borne in mind, however, that hardness and elasticity of paints are proportional to the per cent of pigment and non-volatile vehicle present. The architect or engineer should, it is believed by some, specify a high per cent of pigment where a hard paint is desired, and a high per cent of non-volatile vehicle where a paint of great elasticity is desired. A paint high in pigment has a low spreading capacity; therefore, where great elasticity is desired, it can be accomplished by increasing the per cent of non-volatile vehicle and securing proper thickness by an increased number of coats. The spreading capacity of a paint is reduced by an increase in the per cent of pigment present; in other words, the greater the per cent by volume of pigment, the greater will be thickness of the applied coat. The fineness of the pigment should be such that there

shall be no tendency to run or "weep" when the paint is properly spread out.

The architect or engineer should possess a reasonable knowledge of the chemical composition of all protective coatings for iron and steel. He should know:

(a) Whether there is present in the paint any constituent that would, on oxidation, form mineral acids. The analysis should show whether the vehicle contains sulphur or chlorine, as it is believed by some that such vehicles by decomposition and oxidation cause the formation of corrosive mineral acids.

(b) Whether the vehicle contains lead or manganese, or both. It is believed by some that manganese makes the vehicle dry too rapidly (as compared with lead alone) and to continue drying until the elasticity of the paint is destroyed.

(c) Whether the vehicle contains non-volatile, unsaponifiable matter (usually heavy mineral oil), for, if it does, it is believed that as the drying oil dries it separates from this unsaponifiable matter and an unhomogeneous coating is obtained. It is also believed that heavy mineral oil, if present, causes the paint coating to lose its (tensile) strength on drying and to alligator, leaving large cracks through which corroding gases can reach the metal—also weakening the hold of the paint to the metal surface to which it was applied.

(d) Whether the pigment contains substances that are electrical conductors, as these substances, if present, reduce the insulating capacity of the protective coating and, consequently, under some conditions, it is believed, may favor the destruction of the metal by electrolysis.

(e) Whether the paint contains electrolytes, as, under some conditions, it is believed that the presence of electrolytes favors destruction of the metal by electrolysis. Sulphate of lime is an electrolyte, for instance.

(f) Whether the pigment is basic in its character. It is generally accepted that the tendency for iron and steel to corrode is lessened by the presence of alkalies. It is believed by some that this protective quality is possessed by pigments of a basic nature, such as metallic oxides that are capable of combining with the carbonic acid, etc., in the air and thus preventing its reaching the metal to be protected.

(g) He should know, finally, within reasonable limits, the

other constituents of which the paint is composed, to ensure compliance with specifications and also to explain such peculiarities, good or bad, which the protective coating may exhibit.

To summarize:

1. General tests should be applied to protective coatings, wherever practicable, to show their specific impermeability, hardness and elasticity. Standard methods for making these tests have not yet been formulated, but, when their importance is fully realized, generally acceptable methods will doubtless be proposed.

2. Painting tests should be made showing the spreading capacity and average thickness of coatings.

3. The per cent of pigment and non-volatile vehicle should be determined by weight and by volume (calculated from the per cent by weight and the specific gravity).

4. The per cent of volatile thinner should be determined—also its nature.

5. The fineness of the pigment should be tested; this can be done in many cases by determining the per cent coarser than No. 19 silk cloth.

6. Chemical analysis should show the composition of the vehicle and pigment, within reasonable limits.

J. F. WALKER.—The question of comparative testing of protective coatings has been to me a most interesting subject, but one in which I have always been plunged in chaos on account of the varying results which I have obtained. The so-called accelerated tests are to my mind of little value and to a great extent misleading. Usually, in painting a structure of any kind for test, the work is done under the most favorable circumstances in an endeavor to get the best possible results. In an accelerated test the most abnormal conditions are selected.

In an endeavor to test a coating six points are to be considered, viz: Drying, method of application, adhesion, elasticity, porosity, chemical analysis.

1. *Drying.* This is an important feature and the simplest of all tests, consisting only of applying the paint to a surface and noting the time required before a second coat can be applied. A paint for general purposes should require, I think, not longer than from 8 to 10 hours to set sufficiently for the application of the second coat.

2. *Method of Application.* The method of application I consider a very important element. No matter how good the paint is, if not properly applied the results will be of no value, either in an accelerated or time test. This question of proper application in practice is one which I think the Committee should seriously consider and for which proper recommendations should be made. In applying a paint to a surface, we can readily determine its working qualities, and the range of temperature for which it is adapted.

3. *Adhesion.* Adhesion is a very important factor. A coating that will not adhere to a surface is of no value. This is readily determined by a mere scraping of the paint with a sharp instrument.

4. *Elasticity.* This quality allows the paint to adapt itself to the surface under varying conditions of temperature. The simplest test for this is a scraping of the paint film, noticing whether it peels in long strips or flies off like fine dust.

5. *Porosity.* After all other requirements have been fulfilled, if the paint film is of a porous nature, it is absolutely of no value. Without doubt, this is the most important of all tests, and one concerning which we can as yet get no conclusive result. Numberless tests have been suggested and tried, but with such varying results that little or no light has been thrown on the subject. The tests should be made after the film has been thoroughly aged and hardened. Probably the best is the alternate wet and dry exposure test, using sheet-iron saucers for evaporation.

6. *Chemical Analysis.* After testing a paint for its drying qualities, the engineer should determine the constituents of the coating by a chemical analysis. The results of his analysis will enable him to judge in a measure the probable wearing qualities of the paint.

M. H. WICKHORST.—In making exposure tests of paint samples our practice is to paint pieces of glass, 6 by 8 inches, with one, two and three coats respectively, and expose them on the roof, facing south at an angle of 45° to a horizontal. This we think is about as severe a test as we could make under natural weather conditions.

It would be very desirable if some artificial weathering test could be devised that would be identical in its effects with natural conditions, but we have yet to discover such a test.

THE A. WILHELM COMPANY, REPRESENTED BY C. T. DAVIES.
—Where time is limited, we consider the chemical work by far the most important. Much information as to the wearing qualities and intrinsic value of paint can be thus obtained.

We presume, however, that it is not the intention of the Committee to collect data as to chemical methods for analyzing paints, and we shall therefore confine ourselves to methods for making physical tests. If data as to chemical methods for analyzing paint are desired, we shall be pleased to furnish our views as to what we consider the ideal methods.

Physical Tests. Methods that will eliminate all possible errors, atmospheric and local conditions, and influences from surfaces over which the paint is applied, should be used. To accomplish this, where comparative results are desired, we would make all tests on glass, being careful to have the glass thoroughly clean and free from moisture. This will insure a surface that is at all times uniform, and one that will have no chemical or physical action on the paint.

In connection with this test, we would likewise suggest that exposure tests be made on wrought and cast iron, being careful to have the metal thoroughly pickled, cleaned and dry before applying the paint. The results secured in this way, however, we do not consider sufficiently trustworthy for definite conclusions, nor sufficiently accurate for comparative purposes.

The ideal physical tests are those that will produce the same results at all times and in all places, no matter by whom made, and that may be definitely formulated. These may be classified as follows: covering capacity, fineness, fading, general appearance.

1. *Covering Capacity.* This should be expressed in figures, and we would suggest the following method that we have employed with success: Coat the surface with the paint to be tested. If "ready-mixed," use as received; if in paste, or semi-paste form, thin with a fixed amount of oil and the necessary amount of japan to dry. When this coating is dry, stripe with a flat paint of opposite color, say for a black, red, brown, or any dark-colored paint, use a standard zinc oxide; and for white, gray, etc., use a standard black. When the flat stripes are dry, cover the surface with a second coat of the paint to be tested. Then take the paint, if black, red, brown, or dark color, and dilute with the standard zinc oxide until the shade of stripe is

matched and the covering can be expressed in terms of zinc oxide. If white, gray, etc., match color with the standard black, and express results in terms of black.

2. *Fineness*. Opinions differ as to whether fineness can be best determined by a test for opacity or a test for ability to hold in suspension. We incline to the latter, and know of no better method of determining this than that suggested by Dr. C. B. Dudley in his specifications for freight-car paint for the Pennsylvania Railroad Company, dated May 23, 1893, from which we quote: "The pigment of the paste must be so fine that after having been separated from the oil and freed from moisture, and then thoroughly mixed again with pure raw linseed oil, which has also been freed from moisture, in the proportion of one part oil to one part pigment by weight it will stand the following test, viz: Place a small amount of the above mixture on one end of a strip of dry glass, set the strip vertical where the temperature is maintained at 70° F., and allow it to remain undisturbed for half an hour. The mixture runs down the glass in a narrow stream, and if the pigment is fine enough, the oil and pigment do not separate for at least an inch down from the top of the test." Excepting, however, when the test is to be made general, and not restricted to one class of paint, the amount of oil used should be inversely proportionate to the gravity of the pigment.

3. *Fading*. Apply two coats of the paint on glass, and when thoroughly dry, cover one-half of the surface with dark paper, protecting same with tin. Expose the glass to the action of the elements and remove the covering from time to time and note the difference in shade.

4. *General Appearance*. By no means least in the order of importance is the general appearance of the finished surface. The paint may be fine, cover well, show very little change of color, pass all chemical tests, and still show an unsatisfactory finish. This may be caused by an improper method of manufacture, an excess of dryer, or the use of an aged paint that has become fatty before applying.

The general appearance can be determined by painting over first coated work, and noting the surface; if not homogeneous and shows a tendency to sag, the paint has either been spoiled in manufacture, or has become fatty with age. If drawn or shriveled, the paint has not been properly applied, or an excess quantity of dryer has been used.

DISCUSSION.

Mr. Sabin. A. H. SABIN.—I supposed there would be a full written discussion of this subject, and I had hoped that we would have the report of the committee which is, in itself, a very full discussion, in the hands of the Society at this time. The report is not a report as a single paper which all of the members signed or agreed to, because a committee like ours can not be expected to agree to very many things on the paint question, so each member wrote his own report. While we all agree that impermeability to moisture is one of the necessary conditions which must be satisfied by an effective coating, I think that we also agree that no protective coating has that quality to perfection. Oil films, as is well known, are somewhat porous, and we tend to secure freedom from porosity by superimposing one film on another after the lower one is thoroughly dry. I, with some others, think that varnishes are less porous than oils, but even these are somewhat porous and they must be treated in the same way; that is, they must have several successive coatings.

• I believe that a coating practically impervious to water may be obtained by applying melted asphaltum or something of that kind, but it is impractical to do this on a large scale. We have at various times heard a great deal about the imperviousness of Portland cement, and some attempts are now in progress to make a protective coating by actually putting Portland cement on the metal. This process offers many difficulties, however, and is in a comparatively early stage of development. I doubt if any one will say that very successful results have been yet reached. I think some of those who have been experimenting with it believe that it is useful; it is a matter of which I personally know but little.

It is, however, not only necessary that a coating shall be impervious to moisture when it is put on, but that it shall be impervious after it has been on for some months. I think that, as a rule, railroad people who have perhaps more systematic painting to do than anybody else, would be reasonably satisfied if a paint on ordinary bridges would stand three years and be in

fairly good condition at the end of that time. Comparatively Mr. Sabin.
little paint is in really good condition on steel bridges at the end of three years. Bridges are not usually repainted oftener than once in three years, but many of them are left—in fact, I think, most of them—until they are in pretty bad condition. On the other hand, all paint men who make good, reliable paint can show bridges which have been painted five, six, and seven years, and sometimes ten years, which are in excellent condition. Now, there must be some reason for that. I think that paint men all agree that it is largely due to the proper condition of the metal surface to which the paint is applied, and to the careful and skilful application of a sufficient amount of paint under favorable conditions.

The surface scale should be removed and the metal cleaned, if possible, to the actual metallic iron. This can be done either by pickling, before the structure is erected, or by the sand-blast, and both methods are somewhat expensive. In some cases the sand-blast, at least, is impracticable because it cannot be applied in some places. Last year the Northwestern Railroad undertook to repaint its train shed at Chicago and to clean it first by means of the sand-blast. The passengers made so much complaint about the dust about the station that it had to be given up. It is a matter of common experience that steel which has been cleaned perfectly bright rusts quickly and easily, and the paint must be applied immediately after the cleaning is completed. It is very difficult to get that done. In damp air, and especially by the sea, steel will show a perceptible change in color in two or three hours, and that is a pretty short time for painting. It is known, however, that we sometimes get excellent results without sand-blasting or pickling. The purple scale which is on the iron as it comes from the rolls will in part easily scale off, but some of it adheres with the greatest tenacity. That which can be scaled off should be gotten off at once, but the thin, closely adherent film scale is a good surface to paint on. Most bridges that have shown great durability have been painted on such a surface, for there has not been any appreciable amount of sand-blasting or pickling done in this country, and I think it a good surface to paint on; but rust is not a good surface.

That thin, closely adherent mill-scale is an anhydrous oxide of iron, practically similar to magnetic oxide; it contains no

Mr. Sabin. chemically combined moisture, and from its structure it does not hold uncombined water, which latter is still more objectionable. On the other hand, common rust is not only a hydrated oxide, but it is a spongy substance, which condenses and holds atmospheric moisture mechanically; it contains also other iron salts, the carbonate being probably always present; and other salts may be. Thus, sulphurous acid gas from the use of coal is one of the most common causes of corrosion, and where it is present there will be sulphate of iron in the rust, and sometimes other salts.

The consumer holds that it is not practicable to clean the iron beyond a certain point; and what he wants is paint that can be applied to a rusty surface and give good results, which is out of the question under those conditions.

It seems to me that one of the things which this Society might reasonably investigate would be the relative value of paint sprayed on and paint put on with a brush. Practically there is very little bridge work that is done by means of the spray. It is a much more rapid process than the brush, but there is a good deal of waste of paint in spraying parts like rods and bars, and small pieces in general, because you miss a good deal more than you hit, and the paint floats off in the air and is lost. For that reason it is not more economical than the brush. On practically all structural metal the paint is applied with the brush, but there is a vast difference in the way in which it is applied. The paint should be applied with a good brush. An immense amount of paint on structural work is put on with five-, six-, seven- and eight-inch brushes—flat brushes like whitewash brushes. You get over a lot of surface in that way and it appears that you get a pretty good coating if you do it carefully; but I believe that a round brush or oval brush is the only proper thing to paint with—a good stiff brush with which the paint can be rubbed into the surface of the metal thus getting rid of the air film. There is always a film of air on the surface of the metal and it is necessary to get rid of all air-bubbles and get the paint in contact with the metal as closely as possible. That means work on the part of the men who apply the paint, and that, in turn, means a good foreman and careful inspection. There are several railroads that have gangs of men who do nothing but paint, and who are under the continual supervision of competent foremen. These men understand that they have

got to do their work well and they take pride in it; and on such roads the bridges always look well. Mr. Sabin.

The proper cleaning of the surface and the careful application of the paint, especially the coating that goes on first, are of more importance than the quality of the paint as long as it is fairly good. There are plenty of reasonably good paints on the market. There is of course a difference in paints, and it would be desirable for this Society to work out a scheme, if possible, by which the differences in paints may be discovered. But it would be far more practicable to work out a method of emphasizing the fact that the proper cleaning of the surface of the metal and the proper application of the paint are of primary importance.

I have been talking as though the question of painting applied to structural metal only. As a matter of fact, a hundred times as much paint is put on wood as on metal. People who paint on wood know that if they don't get the surface in reasonably good condition the paint will not stick, and the average quality of painting on wood is vastly better than that of painting on metallic surfaces.

From a chemical standpoint, I think, one difficulty in oil painting is the dryer. I think this should be a low-temperature dryer of which you can not add more than a small percentage and have it produce proper drying effects in the oil. There are two classes of dryers; one which may be called a self-drying dryer, and the other a non-self-drying dryer. The self-drying dryer is a liquid which, if spread out on a glass plate, will dry to a hard film by itself; but there are other dryers which, if spread out by themselves on a glass plate without any mixture of oil, will not dry to a hard film, but will make a greasy film, and that is the kind of dryer which gives the best results in an oil paint. In any paint the percentage of dryer should not be too large. I do not believe that ordinary oil paint or varnish should dry in less than say twelve hours to be dry enough to handle, and I don't think that another coat of paint should be put on in less than a week, and better a couple of weeks. I know that there is a difference of opinion about that, a difference, I may say, which is chiefly between the consumers, or a certain portion of them, and the paint men. Most of the manufacturers object to the use of a very quick-drying paint; but some consumers insist

Mr. Sabin.

that they have got to use it, and that simply means they will use it. I don't believe that permanent results will ever follow from the use of any ordinary paint, such as ordinary oil and varnish paints now in use, unless they are given a good deal of time to dry.

The fact is seldom appreciated that the film of one, two or three coats of paint is only three- or four-thousandths of an inch thick. It is unreasonable to expect a piece of steel which without protection will rust away in five years to a depth of perhaps three-eighths of an inch to be preserved indefinitely by putting on two- or three-thousandths of an inch of paint. The thinness of the paint film is its great weakness, because it is liable to be abraded or scraped off. Often this can not be helped, and for that reason there are many places where I don't think paint is of very much value, or ever can be. Some other means of protecting these places must be devised by covering them with cement or doing something else to protect them. For example, in the case of a low viaduct under which locomotives pass with their smoke-stacks within a few inches of the metal there is a sand-blast action. Such a structure can not be protected with paint. In repainting railroad bridges the paint is sometimes blown off in places before it becomes dry. It is put on as a liquid not supposed to give protection until a dry film is formed, and it is blown away before that. The engineer should be blamed for putting paint in such a place. He should devise something else to put there. When tests are made by putting paint on such places, the results are of absolutely no value to any one.

The President.

THE PRESIDENT.—I am sure we have all been very much interested in what Dr. Sabin has said. It has been our belief for a long time that the methods of application and the preparation of surfaces had a great deal more to do with the value of paints than is commonly supposed, and we are confident that much of the poor results which we have obtained in the painting of steel cars on the Pennsylvania Railroad have been due to improper application of the paints and to mixing inferior materials with those paints to facilitate their application.

Upon one point I cannot agree with Dr. Sabin, namely, the long time which he asks for between coats. This is simply impracticable for two reasons: First, because in the two weeks which he wants for painting a car the car will earn ten times as much as it costs to paint it, and it would be bad policy con-

sequently to hold the car out of service simply for the sake of the paint. But the second reason is still more important, namely, steel cars are made at the rate of one hundred a day, and to allow each car twelve days for painting would require storage for 1,200 cars, and there is not enough track room around any car works to accommodate such a number of cars. Finally, our own experience does not indicate that rapid drying is detrimental to long life of paint. In regard to the test which we propose, namely a little spot of dextrine on glass, which is to be painted over, and then the glass put in water to see whether the water gets through and softens the dextrine underneath, causing the paint layer to peel, we would like to say again, as is said in the report, that this test is based on the supposition that if we can keep water away from the surface with a layer of paint it will not corrode. The test is too new to enable us to draw any important conclusion, but we cannot help feeling that it may contain a germ of value. One point I should like to mention, namely, we have struck a difficulty with this test which we do not yet know how to overcome. It looks as though paints could not be applied to any surface with a brush, without leaving air-bubbles in the layer, which air-bubbles do not disappear during drying, and there is an indication that the water gets in through the ruptured air-bubbles. Up to the present time we have discovered no means of overcoming this difficulty, and would be glad of suggestions. As confirmation of the view that air-bubbles are in paint always, and are the means by which water gets through the layer, it may be sufficient to call attention to the fact that corrosion, especially on car sides, is usually spotted, a good deal more in one place than in another. If the layer of paint is equally pervious to water all over, why should not the action be uniform? Possibly there were air-bubbles at the beginning of each of these spots. It has been proposed to overcome the difficulty of air-bubbles by repeated coats, and it is possible that the value of two- or three-coat work may be explained in this way.

In regard to cleaning surfaces, we are hardly able to follow Dr. Sabin, believing that there is no evidence that if everything detachable is removed from a surface, it is essential to have the surface cleaned down to the metal. The old idea that hydrated oxide of iron parts with a portion of its oxygen, and then takes

The President. up more oxygen from the surface, has never appealed to us, and we do not think there is any evidence that this action takes place. Closely adhering rust is all right to paint over, according to our ideas.

One or two points more: Some very satisfactory results in preventing corrosion have been obtained in painting the Jersey City train shed by Mr. L. H. Barker, the engineer in charge. The method consisted in cleaning the surface of readily detachable material, covering it with a coat of adherent material, paint or asphaltum, or any other adherent material, then covering the surface with paraffine paper, taking pains at the laps, then painting the paraffine paper with paint of the color desired. Two years' experience with this method shows very satisfactory results.

What Dr. Sabin has said in regard to mechanical injury, I am sure none of us can fail to agree with. A coat of paint will not stand the hammer.

Mr. DuComb. W. C. DuCOMB, JR.—In connection with the use of paraffine paper, I should like to say that paraffine itself is sometimes used to preserve the fracture of specimens from rust, especially if the fracture is to be submitted as evidence in court. The paraffine is melted and the broken pieces are covered with it until such time as it is desired to use the pieces, then the paraffine is melted off, leaving the fracture as bright as when the specimen was tested.

Mr. Thompson. G. W. THOMPSON.—This report will prove of very great value, because it brings together the opinions in a true state of the various members of the committee, some of them connected with the manufacturers of paints and some with the use and testing of paints. No matter how just and careful, intelligent and honest any man is, he is more or less biased by his vocation; and when we get opinions from any man, no matter who he is, those opinions must always be taken with a grain of salt. The importance and value of this report will be not so much in the opinions as in the suggestions and statements of fact. Unfortunately, we have more or less of a tendency to generalize too much. If, when we generalize, we state the facts on which our generalization is based, then others can judge whether we are correct or not.

The question of the protection of iron and steel, has in many cases been approached in an entirely wrong attitude. That is pointed out, I think, in that part of the report in which

it is said that no protective coating can be said to be satisfactory under all conditions. There are some conditions where the changes of temperature are great, and what will do in one place will not do in another. So it is of the greatest importance that architects and engineers should understand all about the various paints which they are going to use, and the conditions to which they are to be exposed. Mr. Thompson.

I should like to ask Dr. Dudley in regard to his dextrine test, whether he has thought at all of the possible point of the dextrine being dissolved in the oil of the paint? Linseed oil will, under some conditions, dissolve carbon-hydrates. If dextrine is taken up by the oil it would be natural that the paint when placed in water would allow this dextrine to dissolve and so allow the water to reach the surface underneath.

THE PRESIDENT.—The action of dextrine and oil has not been investigated, at least not by us. The President.

C. N. FORREST.—In regard to air-bubbles, I have noticed that such bubbles are always present when glass is coated with paint, whether this contains pigment of any kind or is on the order of a varnish as Dr. Sabin has described, so the relation between the glass and pigment can hardly influence this fact. Mr. Forrest.

A properly made varnish paint will flow more freely than one containing pigment, and when glass is coated with such a paint it will be observed that nearly all of the air-bubbles escape within a few minutes after it is applied.

Varnishes drying by evaporation, rather than by oxidation, possess a further advantage in that the second coat always disturbs the previous one to a slight extent, thus permitting a further and practically complete removal of all bubbles, and the filling of the space occupied by same with more desirable material.

This feature of certain bituminous paints or varnishes doubtless accounts for their superiority as protective coatings for iron or steel, and their greater capacity to resist the action of water than drying oil paints possess in the dextrine test on glass which has been mentioned by our President.

I. H. WOOLSON.—I wish to say a word about the dextrine problem. I haven't had very much experience in the line of testing paints, but I found on making an investigation the same difficulty that Dr. Dudley referred to. I thought I might overcome the difficulty by using postage stamps pasted on glass, Mr. Woolson.

Mr. Woolson. since the paper would protect the dextrine from injury by oil or water. I made only a few experiments, and of those two or three were failures, but the others were successful. I wish to throw out the idea as a possible solution to the difficulty under discussion.

The President. THE PRESIDENT.—We usually put the test glasses in water and let them stand over night. Most paints containing linseed oil will peel the next morning under this test. Some of the bitumen paints will stand forty-eight hours, and but for the doubt as to whether the layer itself is permeated, or whether it is the air-bubbles, we should feel as though we were on firm ground.

Mr. Voorhees. S. S. VOORHEES.—I would state that I had occasion to test some paint recently, and having heard from Dr. Dudley that none of the paints they had tried had been dried for a period of more than a week, I allowed the paint on these panels of glass to dry forty days, and after immersion in water for about a hundred hours, it was shown that the film was impervious and that no peeling occurred. I think that would indicate in this case that the air-bubbles were not the cause of any water getting through.

The President. THE PRESIDENT.—Did you apply two or three coats?

Mr. Voorhees. MR. VOORHEES.—Three.

Mr. Boynton. C. W. BOYNTON.—I should like to ask Dr. Dudley how the glass was prepared and how the paint was applied in his tests.

The President. THE PRESIDENT.—We use a small soft, flat brush, about one and a half inches wide, for painting.

Mr. Boynton. MR. BOYNTON.—My thought was that the air-bubbles might be eliminated by floating glasses.

The President. THE PRESIDENT.—We tried floating glasses and found in the operation of stirring up the paint to get it uniform that some air got into the paint and we still got air-bubbles. It has been proposed to use gelatine capsules instead of glasses, plunging them into the paint, and allowing the excess to run off, with the expectation that the air-bubbles would be carried with it. The gelatine capsules are then put in water, and if the water gets through the layer the capsules will collapse. This method has not yet been tried.

Mr. McNaughton. MALCOLM MCNAUGHTON.—I should like to ask how far you would take this test as an indication of the value of the different paints against corrosion, regardless of other tests, or could it be made regardless of other tests?

THE PRESIDENT.—This is only one of the steps in the study of the problem. If we could get a paint which would stand this test it would be, we think, a decided step forward, and other features could then be studied. The President.

MR. MCNAUGHTON.—I asked that because it occurs to me that in the greatest number of cases in my experience, corrosion follows the destruction of the paint layer, rather than taking place underneath it. Mr. McNaughton.

J. J. SHUMAN.—I should like to ask an expression of opinion as to the advisability of using raw oil for the first coating of iron or steel. We have a series of records extending over several years which show that paint applied to the bare metal produces much better results than the same paint applied over boiled oil. Mr. Shuman.

C. M. MILLS.—I would state that I have had a few opportunities to observe the effect of coating bridge material with linseed oil at the shops. I have noticed that the material became rusty after exposure to the weather before erection. In the cases noticed the material had been shipped a long distance, so that it was several weeks after shipment before the material come under my notice. Mr. Mills.

I had no opportunity to ascertain the quality of oil used, and am under the impression that it was raw oil. I do not believe that rusting before the first field coats are applied after erection will be prevented by coating with oil at the shops, unless the time elapsing between the coating with oil and the field-painting is short. It appears to me that the delays incident to the erection of material, by which it remains exposed to the weather, and often under very unfavorable conditions, makes the oiling at the shops, as a rule, injudicious, and that paint would be far preferable.

T. D. LYNCH.—I should like to suggest one point, namely, the detrimental effect that may be due to the acids in the oils. Mr. Lynch.

Experience teaches us that in the protection of electrical apparatus it is essential to have no acid in any oil, paint or varnish where they come in contact with the insulation. It is found that the slightest amount of acid will attack the insulation and copper. In view of this fact, why may we not expect a similar action on iron or steel when acid is present in the coatings? Quite recently I had occasion to coat a large shaft with tallow and white lead. The shaft was polished before coating,

Mr. Lyneh. thus presenting a surface easily attacked. After six weeks the coating was removed and, although the shaft had not been removed from a dry building, it was covered with rust over nearly its entire surface.

These are simply suggestions, but it appears to me to be of vital importance to have protective coatings free from acid.

Mr. Wickhorst. MAX. WICKHORST.—I have been listening to the discussion eager for information. In making exposure tests there is a great deal of difficulty in getting results in any sort of reasonable time. I have found that we can hasten results and make pretty fair comparative tests by covering glass with one coat of paint, and then examining its condition with a magnifying glass. Thus we can sometimes get results in a few weeks which would otherwise take as many months, or perhaps extend over two years.

It is my practice in making these tests to expose the sample on the top of a roof at an angle of about forty-five degrees facing south, so as to get the full effect of the sun. I should like to discover some method that will not take even a few weeks. I should like to reduce the time to a few hours, and possibly to make a test of this sort with the films themselves.

Mr. Sabin. MR. SABIN.—I wish to add just a word. I think Dr. Dudley and I do not differ substantially in matters of theory. Dr. Dudley says that if you have an impervious film over your coating of oxide that the oxidation will not proceed any further. Of course I agree perfectly with that, but I started out by saying that there is no such thing as an impervious film.

In practice the films are not entirely impervious, and for that reason the surface of the metal must be thoroughly cleaned and prepared, and the oxide must be removed; and I reiterate the assertion, that the vast majority of manufacturers agree in saying that the durability of paint depends more on the preparation of the surface and the application of the material than on the kind of paint, so long as it is good paint.

Dr. Dudley says you have got to use six or eight-hour paint on steel cars. That may be true. But even so, you could use fourteen-day paint perfectly well and get through with it in a day, if the cars were run into a moderately hot oven. I don't believe in high-temperature baking for paints; but ordinary oil paint can be dried in a temperature of 200° to 250° F. in a very few hours. And as to the matter of providing a plant for baking two or three hundred steel cars, it is a simple thing. If there is

enough of such work, the cost of the plant will disappear in a very short time. We have done a great deal of bigger work than that in the way of baking painted steel. Of course it is going to cost a little more at first, but it might be economical in the end. Mr. Sabin.

THE PRESIDENT.—The question of building ovens in which to dry the paint on cars has been discussed, and it looks as though there might be some favorable outcome. Rapidity of drying is not the only thing which would be accomplished by drying in ovens. The President.

JAMES CHRISTIE.—With reference to accelerated tests for paint, I would say that in our works it has been customary for several years, in addition to the usual acid tests, to have an abrasion test, effected by sand falling from a certain height, and noting the time it takes to remove the paint. This may not be new, but I mention it as being useful. We consider it one of the most useful of comparative tests for paint. Mr. Christie.

W. A. AIKEN.—In the case of the rapid transit work, all heavy material, such as roof beams, is always painted, but we have found out by tests on a limited scale, that this is not necessary in our reinforced concrete walls and the reinforced roof of the Brooklyn extension. Where the specifications call for metal therein to be oiled at the shop we do not coat it at all now. Mr. Aiken.

A. L. JOHNSON.—I have embedded rods, that had been exposed in a warehouse for two years, and were of course more or less rusty in test specimens, which when broken later showed no signs of rust on the bars or concrete adjacent thereto. Mr. Johnson.

I should not object to any rust on metal unless it were sufficient to produce a scale which would prevent the mortar or cement getting under it. If the steel columns of a building were exposed in a yard for two months before erecting the building, without any protection at all, the scale would be a serious matter; and it should be removed before the columns are concreted. But if it is merely a matter of rust stain which can be wiped off with the finger, I am sure there is not the slightest probability but what the alkalinity of the cement will totally destroy that amount of rust.

Two years ago the Turner building in St. Louis, a steel structure, was taken down to give place to an addition to the building adjoining. The floors were of concrete arches. The beams had been painted with red lead when erected twenty years before. The paint was in a perfect state of preservation.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

Your Committee, in presenting this Annual Report, feels that much progress has been made during the last year. Up to this time, the work of the Committee has, of necessity, been that of clearing ground. Now, it feels that its work is fully formulated and properly organized. In the report of this Committee presented in 1903 to the Sixth Annual Meeting of the Society, the following statement occurs:

“It is further considered that the function of this Committee is not to specify any covering or coverings as protective, but to specify tests which coatings must stand to assure maximum efficiency.”

This is the position of the Committee to-day. It is not prepared, and never expects to be prepared, to recommend any particular paint for any particular exposure. It is seeking to discover methods of conducting laboratory tests which will indicate the protective value of a paint under certain known conditions of exposure. Furthermore, it is not willing to recommend specifically any laboratory test whose value has not been demonstrated. The value of a laboratory test depends upon the degree to which it corresponds in its results with actual exposure tests. Your Committee, therefore, has provided sub-committees whose duties are to consider the various phases of this subject. These sub-committees were appointed after a meeting of this Committee (E) in Philadelphia in December last. The titles of these sub-committees, stated in logical order, and their personnel are as follows:

On Standard Methods of Conducting Field Tests:

W. A. Polk, *Chairman*.

L. H. Barker.

Malcolm McNaughton.

On Standard Methods of Conducting Service Tests:

G. W. Thompson, *Chairman*:

W. A. Aiken.

Robert Job.

A. H. Sabin.

J. F. Walker.

On the Permeability of Paint Films:

C. B. Dudley, *Chairman*.

A. H. Sabin.

S. S. Voorhees.

On Permanency of Paint Films:

Malcolm McNaughton, *Chairman*.

A. W. Dow.

C. B. Dudley.

Robert Job.

G. W. Thompson.

On Preparation of Iron and Steel Surfaces for Painting:

J. W. Whitehead, Jr., *Chairman*.

W. A. Polk.

Max H. Wickhorst.

The idea is that the service tests act as a check on the field tests; that laboratory tests as to permeability should be accepted as of value only when found to be in accord with the field and service tests; and that the permanency of a film in its impermeability and other protective qualities should throw light on the results obtained by field and service tests.

The reports of these sub-committees follow.

S. S. VOORHEES,
Chairman.

REPORT OF SUB-COMMITTEE ON
STANDARD METHODS OF CONDUCTING FIELD TESTS.

In presenting this report, we beg to make the following recommendation:

The scope and purpose of the Committee, as we understand it, is to suggest a series of tests which may be carried on by the

General Committee for the purpose of classifying such paints as may come under the notice of engineers, architects, railroad officials and others who may be interested in protective coatings for steel; these tests to be made on the following structures:—Tunnel sections, as the New York subway, railroad bridges exposed to action of locomotive gases, railway bridges not so exposed, highway city bridges and viaducts, highway country bridges and viaducts, elevated railroad structures, the New East River bridge over Blackwell's Island, and the Manhattan bridge, round houses and terminal sheds, gas holders, metal sidings on warehouses, piers, and all varieties of marine painting excepting bottoms.

In outlining a test on any one of these different structures, the Committee would suggest, for instance, that a section, one-eighth of a mile in length be taken in a tunnel; that fifty paint manufacturers be allowed to be represented; and that each manufacturer furnish the material that he wishes to have applied for the purpose of protecting the steel exposed in the tunnel. The manufacturer shall make a deposit of a sufficient amount of money to have the surface prepared for painting and to have the paint analyzed by two reputable chemists. They may apply the paint themselves or they may allow it to be applied under the supervision of a committee which shall be appointed to take charge of the tests. There shall be a director of tests, who shall be appointed by Committee E.

At the time of application, samples of each paint shall be taken by the chemists on the ground, under the eye of the director of tests, the manufacturer being represented. There shall be three quart samples taken from original package, the same to be put in clean containers and shall be sealed in the presence of the director of tests. One of these samples shall be given to each chemist, and the third shall remain in the possession of the Society for the purpose of future identification. The Committee must have duplicate samples of all paints tested for the purpose of identification. The analyses of the various paints shall be made by the chemists appointed by the Committee, and such analyses shall go into the possession of The American Society for Testing Materials.

The application of the paint shall be made under the direct

observation of the director of tests and the Committee. This Committee shall be called "The Committee on Field Tests" and shall be appointed by Committee E. Proper records of the location of the various paints tested shall be kept by the Committee on Tests. At least one week shall elapse between the application of each coat of paint. All the paints should be applied within the same week if possible.

The Committee on Tests shall be continued during the course of the tests which may last for five (5) years, or indefinitely. Vacancies that may occur shall be filled by Committee E, and the Committee on Field Tests shall make periodical reports of the results of the inspection of the paints to Committee E. The consensus of such reports shall be printed in the Annual Proceedings of the Society.

A set of rules shall be formulated for procedure in making the tests, and a copy of the rules shall be forwarded to each manufacturer upon inviting him to participate in the tests. The Committee on Field Tests shall have full authority to make rules in regard to the time of application, and the condition of application under which each paint shall be applied.

The present Committee upon Investigation of Field Tests, as now constituted, has three members; it should have no less than five with a quorum of three, who will have power to carry on the work of the Committee.

There will be difficulty, of course, upon smaller structures in apportioning a large amount of surface, or apportioning a full size member to each manufacturer who wishes to submit a sample for test. Undoubtedly, this question will have to be studied from a thoroughly practical standpoint before it is taken up.

The Committee has been successful in interesting several representative people in this matter of tests. We do not apprehend any difficulty in securing structures upon which to carry on our investigation.

W. A. POLK,
Chairman.

REPORT OF SUB-COMMITTEE ON
STANDARD METHODS OF CONDUCTING SERVICE TESTS.*Method of Preparing Painted Plates for Exposure Tests Under
Service Conditions.*

All service tests should be conducted in sets, so that the results obtained from each set of tests stand in a definite relation to each other, and are only to be compared with the results obtained from another set of service tests relatively. Each set of service tests should be exposed under conditions which are as nearly identical for each member of the set as possible.

Take a sufficient number of sheets of steel, if possible from the same heat, and preferably what is known commercially as "pickled and cold-rolled steel." These sheets of steel should be uniform in size and thickness, preferably No. 10 steel (about $\frac{1}{8}$ " in thickness) 36" long x 24" wide. If "pickled and cold-rolled steel" is not used, steel from a uniform lot is to be cleaned and pickled, as follows:

Dip the plates, if at all greasy, in a hot 10 per cent caustic soda solution, then in hot water, then for a time uniform for each plate (say 10 minutes) in hot 10 per cent sulphuric acid, then in hot water, then in hot 10 per cent carbonate of soda solution, then rinse well in hot water and until the absence of H_2SO_4 or Na_2CO_3 is indicated by failure to secure a precipitate in the wash waters by the addition of $BaCl_2$ solution, and immediately dry in an oven; while hot, pack and dry in powdered caustic lime until wanted for painting; remove all lime dust carefully by a stiff brush before painting. These treating and washing solutions and waters should have a temperature of 190 degrees Fahrenheit, at least. All sheets not uniformly cleaned by this treatment should be rejected. Before painting, the plates should be numbered by making cuts $\frac{1}{8}$ " deep in the edge with a hacksaw.

A suitable frame should be provided, in which the sheet of steel should be placed during handling in the laboratory and shipment to place of exposure. A plain picture frame, laid face down so that the plate can be placed in it, its upper side to be the side to be painted, would be suitable. A table, somewhat larger than the plate to be painted, should be provided and

arranged so as to be accessible (for inspection of plate, etc.) on the four sides. A board of a size such that it will slip readily through the frame should be fastened to the top of the table so that when the frame containing the plate to be painted is laid over this board the plate will be raised out of the frame in a horizontal position suitable for painting. Rubber suction buttons, chewing gum, wax or some such similar device or material can be placed near the corners of the supporting board to keep the plate in position during painting.

Use, in making these tests, a $2'' \times \frac{3}{8}''$ flat chisel-edge flowing varnish brush made of the best quality of boiled and prepared French bristles, the length of bristles outside of ferrule to be between $2\frac{1}{4}''$ and $2\frac{1}{2}''$. There should be one new brush for each paint tested. After use, each brush should be cleaned out thoroughly, first by turpentine and then benzine (all volatile) and allowed to become thoroughly dry before being used for further coats. If desired, each brush may be placed in its respective paint for one hour before using.

A room should be provided, in which to prepare these tests, free from dust and corroding gases or vapors, and maintained at a temperature that will not exceed 85 degrees Fahrenheit or fall lower than 65 degrees, with a free circulation of air.

Before the paints are applied, it shall be agreed either as a result of preliminary tests or in accordance with recommendations from manufacturers as to the spreading rate per gallon, according to which each paint shall be applied, also the number of coats and the time to be allowed for between coats. Ordinarily, a paint shall be considered dry and ready for further painting two days after it shall have become sufficiently dry to resist thumb pressure.

The specific gravity of each paint as it is ready to apply shall be determined by weighing 100 c.c. in a graduated flask at 70 degrees Fahrenheit, multiplying this specific gravity by 8.33 to get the weight of the paint in pounds per gallon, or by 3785.4 to get its weight in grams.

A beam balance, accurate to 10 milligrams, is desirable for the proper conducting of these standard tests.

To conduct a test, place the sheet of steel to be painted horizontally on the described support, clean it very thoroughly;

take a sufficient amount of paint thoroughly mixed and place it in a distemper glass; weigh the glass, paint and brush to be used; find the amount of paint to be applied per coat by the following formula:

A—Spreading rate per gallon adopted.

B—Weight in grams per gallon of paint.

C—Surface to be painted—equal to 6 square feet.

$\frac{C \times B}{A}$ = Amount of paint in grams to be used for each coat.

Apply the paint to the surface, brushing it back and forth until the amount required shall have been applied in a smooth and even coat. Then place the sheet of steel horizontally on a suitable rack with the painted surface upwards and allow it to dry for the length of time agreed upon to start with. Two days before each plate is to receive a second or third coat, it shall be placed in vertical position with free access of air and in bright diffused light. When a second coat shall be applied—if such second coat is called for—it shall be done in the same manner as the first coat; and a third coat, after the second coat has dried—if such third coat is called for—etc., etc.

Preliminary to the making of this test, the thickness of the sheet of steel shall be determined at accurately located points by a delicate micrometer calipers; and when the painting test is completed, the thickness shall again be determined at these points, thereby obtaining the thickness of the paint film.

Before exposing the paint, two striping coats shall be applied around and over the edge, front and back, to a width of one inch. No other paint should be placed on the back of the steel plate, to which should be allowed free access of air.

Test plates should be prepared in triplicate for each paint, with the end in view that after exposure the plate which appears to show the average conditions of the three shall be used for comparison with similarly selected plates painted with other paints.

GUSTAVE W. THOMPSON,
Chairman.

REPORT OF SUB-COMMITTEE ON
THE PERMEABILITY OF PAINT FILMS.

The Sub-committee on Premeability of Paint Films, has only a meagre report to make, owing to extreme pressure of work, which has prevented any elaborate experimentation. Some tentative attempts have been made to determine whether paint films actually were porous or spongy, by studying films under the microscope. Thus far no satisfactory conclusions have been obtained from this study. With the best microscope at the service of the Sub-committee, it was not possible to detect any definite appearance of porosity. The examinations were made by painting a film on glass and then examining the film by both transmitted and reflected light. By neither examination could any spongy appearance be detected in the film. Possibly a better method of experimentation might develop something.

The Sub-committee members are under very great obligations to the studies of Mr. G. W. Thompson, who is a member of the General Committee, for a proposed method of obtaining paint films. (See description of method in the Report of Sub-Committee on Permanency of Paint Films.)

The films that the sub-committee has seen made in this way, seem to offer an admirable chance for studying permeability. The sub-committee has in mind using these as a diaphragm, with the idea of seeing whether the permeability of the film is a question of osmosis, and also further studies.

It is to be regretted that the amount of time at the disposal of the Sub-committee has been so limited, and that the progress has been so small.

C. B. DUDLEY,
Chairman.

REPORT OF SUB-COMMITTEE ON PERMANENCY OF PAINT
FILMS.

The Sub-Committee appointed to investigate the subject "The Permanency of Protective Coatings," beg to report as follows:

The time which has elapsed since the appointment of this committee has not been sufficient to enable it to carry on any

original investigation along the lines developed in its discussion; therefore, at the present time, it is only in a position to point out what it believes to be the common destructive influences which affect the permanency of such coatings and to suggest a plan which seems capable of giving at least rough indications of the relative ability of various coatings to resist any given destructive condition.

Permanency in protective coatings must always be considered relatively as none are absolutely permanent under all conditions. It is recognized that some withstand certain conditions better than others, and a plan which will indicate these differences must be of value. Protective coatings vary in permanency as a result of chemical change, solvent action, physical change as a result of heat and changes of temperature, and abrasion. The chemical change common to all oil paints, and which we call drying, may be said to be the most common destructive agency. This process cannot be stopped when the coating has become firm and tough, but proceeds until it has become brittle and inelastic. The character of the japans added to induce drying seem to have much to do with durability, those which have been made at relatively low temperatures being less destructive than those made at higher temperatures.

The permanency of the film is undoubtedly largely affected by the chemical relations of the pigment to the binding material. For example, if linseed oil and japan are the binding materials, and the pigment is of such a nature that there is chemical action between the pigment and the oil, or the constituents of the japan, the life of the film will usually be short.

Rain water always contains a little ammonia which is a solvent of dried linseed oil, so that there would result a slow solution and washing off of the binding material of the paint. The action must be more rapid in those localities where large quantities of soft coal are burned.

All chemical changes are accelerated by heat, so that heat is ordinarily considered as one of the most destructive forces which protective coatings have to withstand. Paint on the south side of structures fails more rapidly than on the north, simply because of the higher average temperature. The effect of light, independent of heat, on the durability of coatings is obscure.

The departure of a paint film from its best condition toward ultimate failure is usually marked by a decrease of elasticity and an increase of brittleness. When the coating is on a support it is difficult to detect relative differences in these respects. The method of preparing paint films for purposes of investigation, has been to coat plates of zinc and to remove the zinc by dilute sulphuric acid solution. There are two objections to this method, one is that zinc itself has certain drying properties, and second, that dilute sulphuric acid produces slight changes on certain metallic oxides and pigments.

A method has been suggested by Mr. Thompson which does not appear to have any objectionable features. Take a piece of tinned plate, amalgamate this thoroughly with mercury—dry—rub off the excess of mercury and repeat this operation after the end of twelve hours. If this amalgamated surface is painted with linseed oil paint, the paint may be removed from the surface almost intact, when dry, by rolling it on a glass rod $\frac{1}{2}$ inch in diameter, from which it may be unrolled and hung in a proper place until needed for testing. Films so prepared may be subjected to such accelerating and destructive influences as may be desired and their relative behavior noted. Changes in elasticity, weight, specific gravity, shrinkage, tenacity are to be looked for, and when found are to be considered signs of decay.

An investigation along these lines is not of course expected to give exact information. but if in such a test one coating resists any given condition better than others subject to the same conditions, it is a fair assumption that it will do the same in practice.

Whenever a test for resistance to abrasion is needed it is best made by allowing a fine stream of sharp sand to fall from a fixed height upon the coated plate at certain fixed angles. The test should not be made on freshly painted plates but upon such as have been subjected to a moderate degree of heat, so as to bring this coating to a condition it would arrive at in practice after being exposed for a length of time. This, in general, is the suggestion of a means of gaining hurried information as to the relative permanency of protective coatings. It can best be applied to linseed oil coatings, which change most because of chemical alterations, and is not so well applicable to varnish-

like coatings, where the changes are due less to chemical than to physical forces.

MALCOLM MCNAUGHTON,
Chairman.

REPORT OF SUB-COMMITTEE ON PREPARATION OF IRON AND
STEEL SURFACES FOR PAINTING.

In order to secure the best possible result from a preservative coating it is quite necessary to have the surface of the steel free from dirt, rust, detachable mill-scale and grease.

In order to secure this result we would recommend the use of hammers, steel scrapers, and wire brushes. Oil and grease should be removed by the use of benzine.

The process of cleaning steel most talked about and least practiced is the sand blast. The two principal reasons for this are, first, the menace to the output of the shops; second, the cost of the process, in consequence of which it has not been sufficiently practiced to reduce it to a practical process, and the members of this Committee are not in possession of sufficient knowledge regarding the same to make any recommendations.

Some of our members have in the past made considerable inquiries upon the subject, and always met the proposition that it is impracticable owing to the lack of space in the shops for properly doing the work.

If we were in possession of any data to justify such a course we would recommend that specifications for cleaning steel in this manner be insisted upon, and in case these recommendations were insisted upon by the parties in interest, the various shops would, no doubt, provide themselves with ample room to comply with such specifications.

The shop coat of paint should be applied under cover with a temperature not below 50 degrees Fahrenheit. Better results can be obtained at a higher temperature. We further recommend that the shops should not only be warm, but dry and properly ventilated, as the durability of protective coatings is increased when the process of drying is carried on in atmosphere

free from moisture. Increased rapidity of drying is secured at the expense of the durability of the paint.

During erection we recommend an inspection coat. By this we mean all abrasions that have occurred during transportation and erection shall be painted with the same paint and the same color as the shop coat, and then the steel shall be given two field coats, each coat of different color than the preceding coat, in order to facilitate inspection and secure proper application of each coat, and to get the desired results, allowing, of course, sufficient time for drying between coats. The paint may be considered dry when a sliding pressure of the thumb shall fail to remove it.

J. W. WHITEHEAD, JR.,
Chairman of Sub-Committee.

DISCUSSION.

Mr. G. W. THOMPSON.—As to whether paint is permeable or not, little definite knowledge is attainable. Once in a while, we get a suggestion which throws some light on the subject; for instance, Dr. Toch has shown us what he calls “progressive oxidation with blistering.” Where blistering takes place, it seems to me that the film is impermeable; because, if it is not impermeable, the gases generated would go through and no blisters would be formed. So in house painting, on wood, or wherever blistering occurs, it is safe to assume that moisture is underneath and that gases are generated which cannot get through the paint. Painters have been known to say: “We do not use boiled oil for the finishing coat, because it blisters.” If they are right, then boiled oil tends to produce a more impermeable coating than raw oil. These are simply suggestions.

Some time ago, it occurred to me to try to make paint films, thinking that it would be useful in the determination of their permeability under various conditions. I have here paint films made with Prince's Metallic Paint and linseed oil; white lead and linseed oil—this is quite elastic; linseed oil film alone, with just a little varnish added to it; Prussian blue film, which is almost like blue glass in transparency; a varnish film—very inelastic; and a red lead film, which is quite heavy.

As to the question of the permeability of paint films, it occurs to me that some notions which have grown in the last couple of decades are not altogether sound. In the olden time, it was only genuine boiled oil that was used, and there are some manufacturers to-day who make their preservative coatings—practically varnishes—from boiled oil, and yet, without any reflection on these manufacturers, they are ready to blame linseed oil as a protective paint constituent, although they use linseed oil, properly prepared, in their own coatings. If these manufacturers are as wise as this, why should not the consumer be equally wise and use a genuine boiled oil in preparing his own paints? It seems to me that we may have gone too far in the

Mr. Thompson. direction of believing that we can take raw linseed oil and dryer and get durability equal to that obtained when an oil is used that has been heated to 500 or 600° Fahr. From recent observations, I feel that I have reason for the belief that a genuine boiled oil is more durable, more resistant to atmospheric influences and has less of a tendency to become hard and brittle—that is to say, it has more permanency.

Mr. Toch. **MR. MAXIMILIAN TOCH.**—In regard to what Mr. Thompson said about the thickening of linseed oil and using it for exposure, I have looked into that and the ideal oil made of that character is the oil used in making patent leather. That oil is heated to from 550 to 560° Fahr., and the dryer added. I made a series of tests which cost me a large amount of money because I went to patrons and asked them to allow me to paint with paint made of this thickened oil to see how much surface that paint would cover, and how well it would stand against northeast exposure in New York. I have the photographs and hope to give you a talk on that subject some other time. The oil would absorb as much as 18 per cent of oxygen in drying and the volume would increase so much that it would get away entirely from its base. It would not blister but come off in sheets. You know patent leather is only subject to an exposure of a few hours out of the twenty-four, or, perhaps twelve hours, at most, half the time being in the shoe closet at a normal temperature. Unless patent leather is kept under normal conditions it will not last.

I should like to say a word on the question of rapid drying, or dryers. I quite agree with President Dudley that paint that will dry in two hours might be as good as paint that takes a week to dry; but I fear we have overlooked the main issue of the question in not specifying what the word means. The ideal dryer is one which stops oxidization when the film is dry. If you produce that you have a paint which has the longest life. There is, however, another side to that story, and that is, eliminating the question of dryer altogether, why shouldn't a paint be made which would dry by evaporation and answer all the purposes for which it is intended? Why should a piece of board be painted with paint that contains a dryer? Why cannot a film be invented which excludes all these things?

The President. **THE PRESIDENT.**—It is frequently held that the rate of

drying of a paint, is an element in its value, and that slow drying paints are better than rapid drying ones. Our studies have rather led us to think that this statement is more or less fallacious. The drying of paint is a chemical operation, and while time is an element in all chemical operations, long continued time is apparently not essential in the drying of paints, and we believe a paint might dry in two hours, and still be as durable as if it required a week for drying. Our thought and experience have been, that the trouble with rapid drying paints has been poor japans. An experiment which we made some years ago might throw a little light on this subject. Three painted boards were prepared for exposure, two different japans being used to produce drying. Each japan had about half its weight volatile matter, turpentine. The same pigment ground in raw linseed oil was used in all cases, and the paints were diluted for spreading, so that in each case there was 50 per cent by weight of pigment, and 50 per cent by weight of liquid. The difference in the paints was in the amount and kind of japan present. Board No. 1 was painted with two coats, containing only 5 per cent of an oil japan. These coats required 12 to 24 hours for drying. Board No. 3 was painted with two coats, containing 33½ per cent of shellac japan. The other constituents besides the japan in every case were raw linseed oil and pigment. This board No. 3 was second-coated in two hours. Board No. 2 had a coat similar to No. 3 for first coat, and a coat such as was used on No. 1 for second coat. These boards were exposed on roofs and vertically, where they were subjected to smoke from locomotives and the weather for three years, and were then examined by the master painter, who knew nothing of how they were painted. His verdict was that all three were in a magnificent state of preservation, and could have remained three to five years longer. No. 1 was slightly more elastic, as would be expected; No. 2 next, and No. 3 least elastic, but there was no appreciable deterioration in any of them. We are clearly of the opinion that the rate of drying is not the important element that has been believed.

The President.

MR. ROBERT JOB.—Our results have indicated that the quality of the japan makes the greatest possible difference in the durability of the paint film.

Mr. Job.

Mr. Job.

On the one hand, a comparatively large proportion of a well-made, moderately cooked japan has given good service, while on the other hand a much smaller proportion of a hard-cooked japan has caused rapid deterioration. Possibly the difference lies in the difference in the solubility under the two conditions. In the first, the material diffuses uniformly throughout the oil, while the japan when hard-cooked, tends to separate into clots or flakes and thus does not give a uniform mixture with the oil.

Several years ago we took up the problem of drawing up specifications for japan and the results have been exceedingly satisfactory. After a study of the matter we reached the conclusion that it is desirable merely to specify tests which would ensure the qualities which from practice we had found desirable, and to leave the composition almost wholly to the manufacturer. By this means we have found it practicable to get the requisite strength and to ensure suitable cooking of the material, and presence of other properties found necessary to the best service under our conditions, by means of very simple tests which any manufacturer can readily make.

In working out standard specifications for protective coatings for iron and steel our thought has been to follow this same general plan, that is, not to specify an exact composition, but merely certain definitely arranged tests which if complied with, by any material, will render certain good service.

Mr. Harrison.

MR. A. B. HARRISON.—There is one point which has not been brought out in this very interesting discussion, and that is the adhesive qualities of paints, which I think is important. In order that a paint preserve the metal to which it is applied, it is essential that:

First.—It should adhere closely to the surface coated, under all conditions to which the surface is subjected.

Second.—It should be non-porous and unaffected by the action of all acids, alkalies, fumes, gases, water, weather, heat, cold, etc.

To secure a coating having these properties has been my study during the last two years. I having given my undivided time and attention to this subject, having made hundreds of tests and experiments under varying conditions, and the results attained are encouraging.

I learned from authorities that the magnificent sculptured **Mr. Harrison.** slabs of alabaster that adorned the palaces of Babylon and Nineveh, although set thousands of years ago, are still in place. Upon investigation it was found that the material of which this cement is composed, resists decay in almost all its forms. Taking this material for the base or pigment for the coating, by a simple means of refining, using a solvent to reduce the material to liquid form, we secured a coating that I believe to be the nearest approach to a rust-proof coating ever applied to metal. The solvent evaporates quickly after application, leaving the surface coated with a mineral wax composed of hydro-carbon, having a percentage of ozokorite combined by nature, just as nature made it, without addition or adulteration.

Besides resisting the action of all acids, alkalies, water, fumes and gases to a degree that is simply wonderful, its adhesive qualities are phenomenal, and it remains elastic. Pieces of glass or glazed tile, coated, and laid one on the other, seem actually to grow together in a few hours, and cannot be separated.

The remarks of one of our members relative to the abuses to which the coating on steel cars are subjected, bring to mind the report of the master painter of one of our large coal-carrying roads, who, after testing this coating, said: "The use of a sledge on the side of the car failed to do more than spread the coating, and did not expose the metal, and even the coal could not scrape it off the inside of the car."

I solicit co-operation on the part of my fellow members in the investigation of the properties of this coating, and I shall be glad to have the manufacturer send samples to any member who may desire to satisfy himself as to its efficiency.

J. W. WHITEHEAD, JR. (by letter).—Some years ago I went **Mr. Whitehead.** into the subject of preparing steel surfaces for painting to a considerable extent, and discussed it with engineers of various steel plants and assembling shops. My idea at first was favorable to sand-blasting, but on investigation I found opposition on the part of all manufacturers and assemblers of steel on the ground that the object could not be attained by this method within any reasonable limits of time and expense. The engineers of the various companies with whom I discussed this subject

Mr. Whitehead. invariably took the position that, owing to the length of time necessary by this mode of cleaning it would block their mills and shops and thereby reduce their output. Some of them went so far as to say that where specifications called for sand-blasting in the shop or the mill, they would refuse to take the order. They all admitted, however, that it was necessary to develop some plan of getting rid of the mill-scale, as it contains a large percentage of oxygen, and is without doubt a factor of danger which would in time cause the deterioration of the steel on which it was allowed to remain.

Mr. P. T. Berg, Mechanical Engineer of the Homestead Steel Works, Carnegie Steel Company, was especially interested in my inquiry, and I discussed with him, personally and by correspondence, the various plans of cleaning steel surfaces.

In a letter dated September 1st, 1900, he gave me the percentage of the ingredients of his Bessemer and open-hearth steel and said, "that they are combined chemically with the steel and cannot affect the paint" "The scale formed on the surface contains about 72 per cent of iron, the balance being oxygen."

From this analysis of the scale it is plainly evident that the steel before leaving the rolls has already begun to return to its original and natural condition in which it is taken from the mines. The ore is found in an oxidized form, and by chemical and mechanical processes the oxygen is eliminated and the particles of iron are united and turned into steel, a condition entirely unnatural and subject to deteriorations from all atmospheric conditions. The question now is to clean the surface so as to eliminate all traces of oxygen before applying a preservative coating in its present and new condition of life.

Plate-steel from which large members for bridges and other structures are made offers the least trouble in cleaning owing to the manner in which it is treated during rolling. The scale found on its surface is but a very thin film created by its last passage through the rolls before going upon the cooling beds. After being exposed to the atmospheric conditions for a short time, it soon curls up and is easily brushed off. In the case of I-beams and other shapes, the question is quite different, for with every pass through the rolls the scale is thickened and

hardened, and it is impossible to detach it in the ordinary way **Mr. Whitehead.** of shop cleaning.

Noticing the quick action of the elements on the thin mill scale of steel plates, I acted upon the theory that an extended exposure of I-beams and other shapes, to the elements, would cause the scale formed on the surface to act in the same manner as that upon the steel plate, if sufficient time were allowed, and I accordingly made some experiments with a number of new I-beams.

I placed them in the open on wooden horses, and on beam No. 1 I allowed the elements to act in their natural way; on beam No. 2 I sprinkled clear water every morning from a hand-sprinkler; on beam No. 3 I sprinkled diluted acetic acid in like manner, the action of which in the open air would correspond to what we might term "di-oxide," and on beam No. 4 I sprinkled salt water.

I kept this up for sixty days, at the end of which time, the one sprinkled with salt water was very badly rusted; the mill-scale had entirely disappeared and the steel itself had been attacked. Beam No. 3 was in a similar condition, but to a less extent, while on beam No. 2 the mill-scale was in very good condition for cleaning; it had raised from the surface of the steel and was easily detached. Beam No. 1, that had been exposed to the elements only, was in very good condition. It took an additional thirty days before the mill-scale on this beam was in condition to be properly removed, and so far as it was possible to ascertain by a physical examination, no particular bad effects upon the steel had developed.

In addition to these experiments I visited various assembling shops and examined closely the steel which they had in stock after obtaining the dates on which they had received the various lots of steel. I found in every instance that the surface of the steel which they had in stock anywhere from three to four months was in excellent condition for cleaning, that is the shop-scale had been sufficiently affected to be easily removed without affecting the main body of the steel. Where the scale had been removed by handling there were signs of incipient red rust which was easily removed with a wire brush and broom.

Mr. Whitehead,

Mr. E. C. Schankland, of the firm of E. C. & R. M. Schankland, of Chicago, who was Chief Engineer of the Chicago Columbian Exposition, was interested in this subject and made some investigations at about the time to which I allude, and came to the conclusion that the only way to get rid of the shop-scale was to "rust it loose," and having the courage of his convictions he wrote his specifications accordingly. These specifications have given excellent results, as the following copy of a letter to me from Mr. E. C. Schankland, under date of June 7, 1905, will certify:

"The enclosed is the specification for painting for the Dubuque and Wisconsin Bridge over the Mississippi River at Dubuque, Iowa. The bridge was erected in 1901-2.

"The specification was carried out; although the shop, where it was fabricated, kicked vigorously and wrote several times asking permission to put on a shop-coat, saying they did not like work to leave their shop in such an unworkmanlike condition.

"The result was entirely satisfactory, although the metal stayed around for several weeks and was covered with red rust in some cases, yet the mill-scale was almost gone and what was left was easily removed. It was cleaned with wire brushes, and although the regular bridge painters left before much painting was done and green men had to be used, it was a most excellent job of painting and is now in first-class condition. I ascribe the good result mainly to removal of the scale during transportation, shop work, etc., and this because there was no coat of oil or paint to keep the scale on the metal.

"We have used this specification on every job since, but in many cases it has not been carried out, because the owner or architect is fearful that the red rust deteriorates the metal, or they object to its appearance, and in almost every case the shops object, though I imagine the real objection is not that given above.

"Among the buildings where steel work was not painted until after erection were the La Salle Station occupied by the L. S. & M. S. and C. R. I. and P. R. R.; Kent Building; Thomas Church Building; and, if my memory is right, the Chicago Edison, Market Street Sub-Station.

"We are firmly convinced that neither oiling nor painting accessible surfaces until after erection gives very much the best results."

The specifications referred to in Mr. Schankland's letter are as follows:

All material before leaving the mill or shop, to be thoroughly cleaned from all scale or rust.

In riveted work all surfaces coming in contact to be painted before being riveted together. All surfaces not accessible for painting after erection, to receive two coats.

After erection, surfaces to be cleaned wherever necessary, and thoroughly **Mr. Whitehead,** and evenly painted two coats of pure red lead mixed with pure linseed oil, 33 pounds of lead to be used to each gallon of oil in the first coat and 25 pounds of lead for each gallon of oil for the second coat. In the second coat, one pound of the best lamp-black to be added for each six gallons of oil used.

Pins, pin holes, screw threads, and other finished surfaces to be coated with white lead and tallow before being shipped from the shop.

From my own experience and observation, I am satisfied that this is the true solution of the question under discussion. The exceptions to this rule will be only where steel is to be assembled and stored for a number of months before erection.

With the adoption of this system the only parts painted in the shops would be the surfaces coming in contact in riveted work, bottom of bed plates, bearing plates, and any parts that are not accessible for painting after erection. After the steel has been erected a corps of cleaners provided with hammers, steel scrapers and iron brushes, should precede the painters and properly clean all surfaces.

The question of sand-blasting has been thoroughly discussed at various times by parties in interest, and has been practiced to some extent; but, so far as I have been able to learn, it has never been reduced to a scientific or practical basis to the extent that it ceases to be a menace and hindrance to the manufacturers of steel. In fact the information obtained through the interviews which I have had, not only with the superintendents of steel mills and assembling shops, but also with the superintendents of railroad companies and railroad construction companies, who have done sand-blasting in the field, shows that so far as their experience is concerned this method is impracticable and does not really secure the desired results within reasonable cost. It is a question of wearing away the mill-scale by the force of the sand-blast rather than its removal by disruption. The time required is altogether too long, and hence this process is too expensive.

Sand-blasting brings up the question of shop output. The majority of the assembling shops are altogether too small for the output desired by their owners and in consequence of this fact the cleaning of the steel, before applying the shop-coat of paint, is sadly neglected. Exceptions to this rule are rare, and where

Mr. Whitehead. the right methods are adhered to the results are apparent to even a casual observer. Such shops are well-known and esteemed by all of the manufacturers of paints of the higher grades.

By the neglect of proper cleaning, the assemblers become the steel's worst enemy. The structural engineer figures the minimum amount of steel to carry the maximum load, using a reasonable factor of safety to overcome any defects of manufacturing. He assumes that all deteriorating elements such as mill-scale, dirt, and rust will be removed before the preservative coating is applied which is intended to maintain the steel in good condition indefinitely. If the shop neglects its work by omitting the most essential part, namely: the proper cleaning of the surface of the steel before applying the preservative coating, then that shop becomes a factor of danger of which the engineer has taken no account in his calculations. I believe that I voice the sentiments of all engineers and investors when I caution the assemblers to stop in their rush to dispose of tonnage and to prepare the surface of their product properly before painting, or else this neglect may bring about the use of some other material of construction. This subject is, in fact, under discussion in all quarters, owing largely to the rapid deterioration to which steel is subject, caused primarily by its treatment before passing from the hands of the assembler.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

As stated in the last report of this Committee, the work of clearing the ground during the past three years has prepared the way for such a series of practical tests as are now reported. The plan followed during the past year of specializing the work of the general Committee by sub-committees will hasten the final solution of the problem materially. The report and recommendations of sub-committee on Field and Service Tests presented in the annual report of last year has been the basis of the following tests:

The structure placed at the disposal of the Committee is a part of the new double-track deck bridge erected by the Pennsylvania Railroad Company at Havre de Grace. This bridge consists of 17 fixed spans, including two 192 ft., seven 195 ft. 5 in., and eight 255 ft., center to center of end pins, and one draw span, 277 ft. 2 in., center to center of end pins. The trusses are about 30 feet deep and the panels 29 feet long. The entire bridge contains some 21,000,000 pounds of steel.

A through bridge would perhaps have offered, in some respects, more favorable conditions for the test, as the effect of smoke and gases from the locomotives could have been noted on the overhead parts of the structure, and ease of inspection would have been increased. These objections are, however, not vital, while the advantages will be practically uniform conditions throughout the entire length of the bridge, severe atmospheric conditions, and permanence of the structure.

The Society having no funds for such a series of tests, paint manufacturers were requested to aid the Committee by donations of funds for the preparation of surface and application of paint, and also to supply the paint they desired to have tested.

To bring the test to their attention, the following circular was issued:

WASHINGTON, D. C., January 31, 1906.

Dear Sirs:-

The Pennsylvania R. R. Co. have kindly placed at the disposal of Committee E of the American Society for Testing Materials a

whole or a part of their new bridge at Havre de Grace, Md., for the purpose of making extensive field tests of preservative coatings.

It is the purpose of this communication to give such information as to the details of the proposed test as to enable each manufacturer to determine whether or not he will enter.

The membership of Committee E is as follows:

S. S. Voorhees, Engineer of Tests, Supervising Architect's Office, U. S. Treasury Department, Washington, D. C., Chairman.

CONSUMERS.

Dr. C. B. Dudley, Chemist, Pennsylvania R. R., Altoona, Pa.
 Mr. W. A. Aiken, 613 Empire Building, Pittsburg, Pa.
 Mr. Robt. Job, Chemist, Philadelphia and Reading Ry., Reading, Pa.
 Mr. A. W. Dow, Washington, D. C.
 Mr. Max Wickhorst, Engineer of Tests, Chicago, Burlington and Quincy R. R., Aurora, Ill.
 Mr. L. H. Barker, Pennsylvania R. R., Jersey City, N. J.
 Mr. Wirt Tassin, Washington, D. C.
 Mr. Wm. R. Webster, 411 Walnut St., Philadelphia, Pa.
 Mr. James Christie, Chief Mechanical Engineer, American Bridge Co., Pencoyd, Pa.
 Mr. McIlheney, New York City.
 Mr. J. R. Onderdonk, Engineer of Tests, Baltimore and Ohio R. R., Mt. Clair, Baltimore, Md.
 Mr. George Heckel, 636 Bourse Building, Philadelphia, Pa.

PRODUCERS.

Mr. Malcolm McNaughton, Jersey City, N. J.
 Mr. C. O. Collins, Niagara Falls, N. Y.
 Mr. Spencer Newberry, Sandusky, Ohio.
 Mr. W. A. Polk, 42 Hudson St., New York City.
 Mr. A. H. Sabin, 432 Sanford Ave, Flushing, L. I., N. Y.
 Mr. G. W. Thompson, 129 York St., Brooklyn, N. Y.
 Mr. J. W. Whitehead, Jr., 1 Madison Ave., New York City
 Mr. C. N. Forrest, Long Island City, N. Y.
 Mr. J. F. Walker, Bridgeport, Pa.
 Mr. Chas. J. Davies, Reading, Pa.

It is the policy of the American Society for Testing Materials to maintain a proper balance in all committees of the Society between the producers and the consumers; the chairman of the general committee, however, is an engineer or a consumer, so that the chairman will have the deciding voice.

The structure at our disposal is a double-track deck bridge, the trusses of which are about thirty feet deep and each panel about twenty-nine feet long. It is proposed that an entire cross section of this bridge,

about twenty feet wide, double track—one or two panels in length—be assigned for each test, excepting the floor system which has been painted. The painting is to be done as soon as settled spring weather is reached in April and May.

In addition to the field tests above mentioned, there will be an auxiliary service test as follows:

It is proposed to paint a number of panels of sheet steel carefully prepared so as to secure uniformity of conditions with the various paints to be used; these paints are to be exposed alongside of the particular paint sections to which they correspond. The proposition is to have nine plates painted with each paint, three of these to be spread out at one uniform rate, a second three spread at another uniform rate, and the remaining three spread at a third uniform rate—three coats—the rates being, say 600, 900, and 1,200 square feet per gallon for oil paints and 300, 600, and 900 square feet for paints containing much volatile thinner. The work will of necessity be conducted under the close supervision of a Director of Tests. The United States Steel Corporation has promised to contribute the plates for these tests free of charge.

The estimated expenses of this trial, including the preparation of the surface, application of three coats of paint, the services of a Director of Tests and helpers, analyses of the samples in duplicate, cost of distribution and storage of material, etc., will be as follows: Paint, cleaning and application, \$3.00 per running foot; the salary of a Director of Tests and helpers, \$500.00; workshop and storage room, \$1,000.00, and analyses of paint per sample, \$20.00.

On this assumption, based on participation by varying numbers of manufacturers, the following table is approximated:

Manufacturers:	50.	40.	30.	20.
30 feet	\$160.00	\$167.50	\$180.00	\$205.00
60 feet	252.50	260.00	274.00	300.00

The estimate of \$1,000.00 for store-shed and workshop will be reduced several hundred dollars if cars are secured for this purpose. The amount of paint required is estimated at from fifty to seventy-five gallons per panel of thirty feet long. The committee feels confident that the figures given will considerably more than cover the expenses of the test.

The manufacturers are expected to give a description of their paint for classification purposes, and are further requested to give detailed instruction in regard to the best method of applying the paint; and the director of tests will see that these instructions are observed. The surface of the metal will be mechanically cleaned with hammers, steel scrapers and wire brushes, so that all detachable mill scale, rust and dirt are removed; any oil and grease will be removed by benzine.

The Society has no fund available for this trial, and it will be necessary for the manufacturers to make a deposit sufficient to cover their share of the expenses. Any unused portion will be refunded.

A Director of Tests shall be appointed by Committee E. The details of conducting the test are to be determined by Committee E, and so framed as to be eminently fair to each competitor and to the paints themselves. The steel is now covered by a shop coat of linseed oil. Before the application of any paint this will be cleaned off as thoroughly as possible. The Director of Tests shall determine when the surfaces are sufficiently cleaned.

The paint shall not be applied in rainy or foggy weather, or when the humidity exceeds average conditions.

The Committee hopes that the information given is full enough to enable the manufacturers to decide on the advisability of entering this trial.

Will you please give this matter your immediate attention, and inform me at your earliest convenience if you desire to aid the Committee in this matter?

Very truly yours,
S. S. VOORHEES.

Replies from some 20 paint manufacturers were received in response to this circular, stating their willingness to aid the Committee to the extent desired. Accordingly the question of cost was figured out on the basis of 20 panels of 30 feet each, and a set of questions was framed covering composition of paint, etc., as embodied in the following letter:

Gentlemen:

You are advised that the paint test to be made on the Pennsylvania Railroad bridge over the Susquehanna River at Havre de Grace will be started immediately. Some twenty paint manufacturers have signified their intention of aiding the Committee in these tests.

It has been decided that each paint will be allowed one panel, practically 30 ft., but if a manufacturer desires to submit more than one paint or expose more than one panel, additional space on the above unit basis will be assigned them.

It has also been decided that the surface shall be uniformly cleaned with wire brushes, scrapers and hammers; oil and grease to be removed with benzine.

It has further been decided that either two or three coats shall be applied as desired by the manufacturer. There is no color restriction for under coats, but final coat must be black, dark brown, dark drab, or some neutral color.

The panels used for these tests will be entirely over water and will extend continuously north from draw.

The actual space allotted to each paint will be determined by lot.

The results obtained by this investigation of the American Society for Testing Materials are intended to be of scientific value to the engineer

and to aid manufacturers in producing paint which will meet certain conditions and are not to advertise any particular brand of paint. With this in mind, the following series of questions have been framed by the Committee so as to enable them to classify the paints used in these tests:

Character, composition, and description of the paint for the purpose of classification and the general information of the Committee; also such other information as the producer is willing to have published.

Information is desired under the following heads, giving at least the commercial name, and the proportion, amount or percentage of each ingredient:

- A. Pigment.
- B. Volatile thinner.
- C. Vehicle or liquid non-volatile matter.

Particular information is desired as to the following:

- (1) Saponifiable oils, *i. e.* linseed, etc.
 - (2) Resinous matters, *i. e.* rosin and gums.
 - (3) Bituminous matters, *i. e.* asphaltum, pitch, etc.
 - (4) Non-saponifiable oils, as petroleum, rosin oil, etc.
- D. Mineral matter such as lead, manganese, lime, etc., other than that present as pigment.

This information is not intended to include trade secrets or particular methods of treatment or manufacture of the constituents.

Further you will please furnish the Committee with detailed information as to the manner in which you recommend that your paint should be applied, it being understood that unless you supply special brushes, a standard round brush will be used.

Finally you will kindly inform the Committee at what price you would be prepared to supply the paint submitted, under present market conditions.

Will you please answer these questions as fully as possible and return to chairman of Committee, together with check for \$205 (per panel of 30 ft.), made out to Joseph F. Walker, Secretary of Committee. The unused portion of this sum will be refunded.

Work will be started immediately and instructions as to shipping will be sent shortly.

Yours truly,

S. S. VOORHEES,
Chairman.

The replies to the circular letter were to be used by the Committee, as stated, in classifying paints submitted.

Unfortunately these questions on composition were regarded as too searching by many paint manufacturers on the ground that if answered they would disclose trade secrets and methods of manufacture. As the tests were seriously jeopardized by these questions they were withdrawn and only such information

requested as the manufacturers were willing to present for publication, together with the price of the paint submitted, at present market conditions.

Under this arrangement paint manufacturers have submitted 18 samples of paint for test, together with the necessary funds for preparation of surface and application.

Through the assistance of Mr. George S. Webster, Chief Engineer and Surveyor, Bureau of Surveys, Philadelphia, Pa., Mr. F. H. Cubberley, Assistant Engineer in the Division of Bridges of the above Bureau, has been granted leave of absence so as to serve as Director of Tests in charge of this work.

The space assigned to the Committee by the Pennsylvania Railroad consists of two spans entirely over water, from the fifth pier north of the draw to the Perryville end of the bridge. These spans consist of nine equal panels about 30 feet long. The space will be divided through the middle of each panel so as to include a vertical member and half the tie rods for each paint.

The building occupied by the contractors during construction of the bridge will be used for the storage of samples, preparation and painting of panels, weighing of paint applied to the bridge, etc.

The service panels will be attached to the I beams on the south side of the bridge on panels where its respective paint has been applied.

The Director of Tests will be assisted by one of the painters of the Pennsylvania Railroad shops at Wilmington, Del., and a painter who has been trained by Mr. G. W. Thompson, of the National Lead Company, in the very important work of painting panels at a fixed spreading rate.

The Director of Tests will be governed by the following general instructions:

INSTRUCTIONS FOR THE DIRECTOR OF TESTS.

In connection with tests of protective coatings on Pennsylvania Railroad Bridge at Havre de Grace, Md., as issued by authority of Committee E of the American Society for Testing Materials.

The Director of Tests shall have full supervision and charge of the paints submitted for tests and of the work and conditions of application unless otherwise specified by individual manufacturers.

He shall receive all paint submitted for test and shall retain the

same in his possession until issued for work. On the container of each lot of paint he shall paint in indelible black letters the number assigned to the manufacturer of said paint by the Committee as determined by lot. Paints submitted by other manufacturers subsequent to this date shall receive consecutive numbers in order of receipt.

After attaching to the packages the identifying numbers the Director of Tests shall, with red paint, entirely obliterate from the packages the names of the manufacturers and all other identifying marks, excepting the designating numbers as aforesaid.

To each individual paint shall be assigned a single complete panel or member of the bridge, which panel shall be numbered corresponding to the numbers of the packages of paint to be applied. The paint used on each panel shall be that corresponding in number to the number of the panel.

The Director shall make a report of the condition of the unopened packages and of the contents of each package when opened, retaining full details of marks, etc., on the packages before these are obliterated. After obliteration of the marks each paint shall be known only by the number.

Before the beginning of work on any section of the bridge, the Director shall see that the surface has been properly prepared in accordance with the instructions of the Committee as detailed in its circular letter of January 31st, which shall also govern him in other details in any case where specific instructions are not herein given.

The Director is provided with a wet and dry bulb thermometer and with a standard thermometer, and it shall be his duty to make three daily observations with each, one at the time of beginning work, the second at noon and the third at the time of ending work for the day; and in connection with the number of each paint being applied during that day, the temperature and humidity at these three periods of the day shall be recorded, it being understood that no paint used in this test shall be applied on any day when the humidity exceeds about 80 per cent. The Director is also expected to make general notes regarding the state of the weather at the time of application of each individual paint.

Paint for use shall be issued by the Director by number, and the quantity issued shall be recorded in each instance, and the remainder left after the completion of the work shall also be weighed so as to give definite information as to the spreading rate of each individual paint.

Where specific instructions as to the mode of application or other details shall have been furnished by the manufacturer, the Director shall see that such instructions are followed explicitly by the workmen. In case no such instructions have been furnished by the manufacturer, the Director shall have general supervisory work in accordance with the provisions of the Committee's circular letter of January 31 before referred to, which shall govern him in all respects.

In the course of application of each individual sample the Director

shall obtain from the workmen general information as to the working qualities of the paint, as well as such other particulars as may suggest themselves to him as useful. In each instance he shall also note particularly the rate of drying and the physical appearance of each coat.

In regard to the number of coatings to be applied in each instance the Director shall follow the markings on the separate packages of paint, and he shall record in connection with each the weight of paint required for each coat applied. In case no instructions have been given by the the manufacturer as to the time to be allowed between coats, the instructions of the Committee as detailed in its circular letter of January 31 shall rule: that is, five days minimum between coats. No thinning or other additions to any paint shall be allowed by the Director unless the manufacturer of any paint shall have otherwise directed, when the manufacturer's directions shall be carefully observed.

The Director shall make daily reports to the Chairman of the Committee according to instructions to be provided by said Chairman.

The painting of the check panels provided for by the Committee shall be under the general supervision of Mr. Ekey, but the Director shall make careful note of all details in regard thereto in connection with his notes on the general work.

The salary of the Director of Tests shall be at the rate of \$150.00 per month; his actual traveling expenses in connection with the work to be paid by the Committee, who shall also pay for necessary labor in connection with the Director's work on the tests.

The Committee will see that the above conditions are strictly observed, and assure the paint manufacturers that the paints will be properly applied to clean surfaces.

The actual painting of the bridge is being done by the firm of J. W. Webber and Sons of Philadelphia, the contractor employed by the Pennsylvania Railroad. Mr. Webber appreciates the conditions of the test and assures the Committee of his hearty support and cooperation in maintaining the above conditions.

In presenting this report to the Society it is realized that there will be more or less criticism both now and as the test proceeds and as results are obtained, but it will be appreciated that this report is the result of long, conscientious, and laborious work on the part of the Committee. The interests and conditions entering into the problem of protecting iron and steel are as different as the pigments used in the paints.

All of these conditions have been harmonized as far as possible, variables eliminated to the utmost, all questions of bias, prejudice, or interest controlled, so that the Committee expects to place in

the hands of the Society valuable data on the protection afforded by paint when applied to bridge steel in this general latitude.

A comparison of the paint films on the service panels and on the full sized structure should determine the value of perfectly cleaned surfaces painted under the most favorable conditions with known amounts of paint.

This report can only be considered a report of progress, the results are to be obtained as they develop and are determined on inspection by the Committee.

It is hoped, however, that this test is only the beginning. Other tests should follow on different types of structures, arranged on fundamentally different lines of attack to eliminate even more completely some elements of uncertainty.

The Chairman of the Sub-Committee on the Preparation of Iron and Steel Surfaces for Painting recently addressed a circular letter of inquiry to a number of firms and individuals prominently interested in the subject which, together with the replies thereto, appears as an appendix to this report.

Respectfully submitted on behalf of the Committee,

S. S. VOORHEES,
Chairman.

JOSEPH F. WALKER,
Secretary.

APPENDIX.

The chairman of the sub-committee of Committee E on the Preparation of Iron and Steel Surfaces for Painting addressed the following letter of inquiry to a number of users and manufacturers of preservative coatings:

DEAR SIR:—

I herewith enclose a reprint from the Proceedings of the "American Society for Testing Materials" on the "Preparation of Steel Surfaces for Preservative Coatings"*.

The general practice of the assemblers does not admit of very careful cleaning of steel surfaces before painting, and as a rule, is not urgently insisted upon by the engineers in charge. It is a known fact that mill scale contains a large percentage of Oxygen and that it induces further corrosion, which necessitates its removal from the surface, as it is destructive to both the steel and the preservative coating.

It appears to me this question should be thoroughly discussed in engineering circles in order to arrive at some definite plan that is both practicable and least expensive, by which the mill scale can be disposed of before painting and then to insist that the plan be carried out.

I ask for your criticism of this article and suggestions as to how to obtain the results desired, as it is my wish to get the opinions on this subject of the leading engineers and architects of the country and of others interested in this class of construction, that I may tabulate them in the form of a report to present at the next annual meeting of the "American Society for Testing Materials."

(Signed) J. W. WHITEHEAD, JR.,

*Chairman of Sub-Committee on
Preparation of Iron and Steel Surfaces for Painting.*

The following replies to this inquiry, given in alphabetic order of the writers, were received:

From Alfred P. Boller, of Boller and Hodge, Consulting Engineers:

In reply to your inquiry concerning the preparation of iron and steel surfaces for painting, I would say that the importance of the subject cannot be overrated. It has long claimed my thoughts and attention, but I

* Vol. V, p. 95.

have never yet come across a satisfactory workable scheme in these days of "rush tonnage." Sand blasting is out of the question as a commercial method, it being utterly impracticable in general shop practice, except possibly in some special cases, where time and cost are no object. The removal of scale in the shop during fabrication can only be very partially done, as the time element required for its entire loosening cannot be considered in modern shop practice, where any delay in the sequence of operations is impossible.

As scale is admittedly a bad condition over which to paint, and as exposure will shortly loosen it so as to enable its removal by brushing or scraping, and having in view practicable shop conditions, it seems most reasonable to omit all shop painting as proposed by you, and let nature put in its work after erection, until the scale is so loosened up that it can be scraped and brushed off, when a fair surface for receiving a priming coat can be obtained, which priming can be well and properly done, as time is no object at the expense of thoroughness.

I notice in the Proceedings of the American Society for Testing Materials Mr. Shankland not only endorses the views you have advanced, but has put them into practice on important structures with satisfactory results, so far as three years show up.

I am inclined to think with you that the only practicable method of properly priming structural steel is to do it after erection when the mill scale has become loose, instead of at the shop, except for such parts as may be inaccessible in the field.

From F. O. Bunnell, Engineer of Tests, Chicago, Rock Island and Pacific Railway:

Answering your inquiry, relative to method for removing scale from structural material, I would state that my personal experience in dealing with this subject has been quite limited. However, I have always felt that the manufacturers, for some reason or other, were not favorably disposed toward developing a sand-blast system. I believe that with the earnest co-operation with the manufacturers in developing this system, a more favorable showing can be made with the sand-blast system than has been made heretofore.

From F. P. Chessman, National Paint Works:

I beg to quote herewith from my booklet, which covers the subject according to our belief, "As to the best methods of preparing metal surfaces for painting".

We have recently had our attention called to a case where the metal had been prepared by sand-blasting and the surface had been so highly polished and smoothed by the sand-blasting that the paint did not adhere, showing that one can get too much of a good thing in sand-blasting as well as in other matters.

TECHNICAL PAINTS FOR METAL.

1. Poor surface and improper application.

As before stated more paint is ruined by poor application than in any other way; hence, we class it as the greatest cause for the failure of paint. It has been our experience that not once in twenty times is the surface free from corrosion, mill-scale, grease or dirt when the paint is applied. The painter is generally not a skilled mechanic, and the paint is put on under all kinds of temperature and degrees of moisture, often rained, frosted or snowed on before dry; also frequently thinned with cheap worthless oils and japans, and the greatest wonder is that, under these conditions, it stands as well as it does.

It makes a vast difference in the durability of the paint as to the character of the surface to which it is to be applied. If the steel is rolled cold or nearly cold the scale will come off much quicker and easier than if it is rolled hot; when rolled hot the scale is pressed in and takes many months frequently before working free, then it carries the paint with it.

Pickling the metal at the mill is the best method for removing mill scale. The next best operation is the sand-blast at the mill. It costs from 75 cents to \$2.00 per ton for pickling, and from 60 cents to \$1.75 per ton for sand-blasting. When the metal is not cleaned at the mill to obtain the greatest durability on work that can be reached to be cleaned off, it would be best to apply only a shop coat of our No. 51, then after this is allowed to stand from six months to a year, depending upon whether the steel was hot or cold rolled, this first coating should be completely removed by burning off with the painter's torch, first giving the metal a coat of benzine. This is our first choice, as it removes the moisture as well as the scale, or by sand-blasting as a second choice, or with wire brushes, which, however, do not do the work as well as it should be done. Then two, or better still three, coats of paint applied, the kind of paint depending on location and condition of exposure.

We regret to say, however, that we do not believe that this ideal method of properly preparing the surface will be followed by many, as they will think it rather expensive, and yet it would prove itself the cheapest in the long run.

From Edward K. Coe, Assistant City Engineer, Duluth, Minn.:

My experience in preparing steel for painting is not extensive, but your discussion came at the right time to give me valued support, when I was receiving much adverse criticism for having 125 tons of steel erected without a shop coat of paint, as an experiment. The steel was exposed to two months of rainy weather and accumulated a coat of red rust. This was removed with hammer and wire brushes, leaving a bright surface on which to paint. Thus far the results seem better than those usually had. I offer this merely as a straw in corroboration of your evidence and that of Mr. Shankland. I may add that I was moved to the experiment by having seen, in 1904, a 2½-inch anchor bolt, 9 feet long, which had been

bedded two years in concrete, break at the bottom nut and pull out. It had doubtless been placed when too new.

From J. B. French, Bridge Engineer, the Long Island Railroad Company:

I have read your discussion with much interest and though we have not yet gone as far as to specify that steel work shall not be painted in the shop, except where inaccessible after erection, I am fast coming to the conclusion that that course is best calculated to meet the existing conditions.

Shop painting as now done in most shops frequently does more harm than good, and as long as present conditions continue, it seems impossible to improve the practice. The difficulty is almost entirely a matter of workmanship including both the preparation of the surfaces and the application of the paint, and is largely due to lack of room in the shops and shipping yards and to the cheap labor employed. Our experience is that more harm is done by putting on too much paint rather than too little, providing the surfaces are covered at all.

We have recently been getting a large amount of steel work for construction in which, after erection, it will be either partially or entirely covered with Portland cement concrete, or mortar, and to cover this class of construction our specification reads—"that surfaces which the construction plans show are to be in contact with concrete or Portland cement mortar, shall not be painted." For various causes much of this steel work has been exposed to the weather for six to eight months before the concrete has been placed to cover it, and while it has become largely covered with red rust, it has cost very little to do the necessary cleaning to allow the concrete to be deposited. No attempt is being made, however, to take off more than the rough flakes and scale, the thin red film being considered as doing no harm where it is to be covered by concrete.

The only objection to having the shop coat omitted from surfaces which are accessible after erection, arises from the uncertainty in regard to the time which will elapse after the delivery of the material and before it can be erected. It would seem desirable, therefore, if this interval is likely to be longer than two or three months, that a coat of thin paint should be applied when the material is unloaded for storage, and in the case of railroad companies this should be done by their own forces. It is the present practice of this Company to purchase the paint and to do all the painting which is to be done after the material is delivered, and where the purchaser has sufficient work to maintain such an organization that is undoubtedly the wise course to pursue.

Under present conditions, therefore, the writer considers that it is useless to agitate a modification of the specified requirements for shop painting other than to cut out the shop coats, except for assembling and for the surfaces inaccessible after erection, altogether, and to have all further painting done by the purchaser after the material is delivered.

From Phelps Johnson, Engineer, Dominion Bridge Company, Limited:

I have had no practical experience whatever with sand-blasting or other special methods of preparing steel and iron for painting. In my experience I have found that an exposure to the weather for three or four months will ordinarily loosen nearly all the mill scale adhering to rolled material, and have considered that the subsequent removal by steel brushes of the slight coating of rust powder that is formed leaves the material in the best practicable shape for receiving the paint. I am of the opinion that the exposure to the weather may be prolonged to say twenty-four months without appreciable waste of metal or injurious pitting or roughening of the surfaces, and that there is but a slight increase in the labor necessary to brush the surface clean for painting. The presence of mill scale on the material when painting may be objectionable, but when it is considered that probably 95 per cent. of all bridge material is worked up, painted and put out from the shops without more than a few days, or at most a few weeks, exposure to the weather, the injurious effect of the mill scale is not in practice very apparent.

From Gustav Lindenthal, Consulting Engineer:

It is true that mill scale contains a large percentage of Oxygen, but it is not true that it induces further corrosion, which necessitates its removal from the surface.

Mill scale is simply the magnetic iron oxide, which is insoluble in most acids, and an excellent preservative of the metal underneath, always provided that it tightly adheres to the surface of the metal. Years ago processes were used to produce artificially, with the aid of superheated steam, on the steel heated to redness, a coat of magnetic oxide of iron, the chemical composition of which is the same as that of the ordinary scale. A scale tightly adhering to the surface is a preservative against oxidation, by reason of holding water by capillary action, which, coming in contact with the metal surface under the loose scale, corrodes the same, and thereafter corrosion progresses as usual at a geometrical ratio, scale or no scale.

I consider the use of sand-blast for the cleaning of metal surfaces not only useless, but detrimental.

A process of cleaning which will leave tightly adhering scale on the metal and remove the loose scale is to be commended. Paint in its multifarious forms depends upon linseed oil forming a protective skin. The mixture of powdered solid bodies for thickening the paint must not mislead us into the belief that these admixtures afford greater protection than does the linseed oil.

The problem of painting iron and steel is not yet solved, in spite of the volumes of papers, discussions and reports on investigations which encumber the bookshelves.

From A. H. Sabin, Chemist:

My opinions you know pretty well; they have not changed. You will find them in my book, "Technology of Paint and Varnish." Also in a pamphlet on "Theory and Practice of Painting on Metal," from which I quote as follows:

SPECIFICATIONS FOR BEST WORK.

All iron and steel, after being shaped, punched, bored and otherwise made ready for assembling, must be cleaned by the sand-blast or other equally efficient means, so as to show, in all parts, the grayish-white color of the metal.

The cleaning of structural steel work by the use of the sand-blast is probably the simplest and most satisfactory way to have it done. The great objection to this, as to all such work, is the cost. Since there are practically no plants for doing such work in bridge shops—in fact there are no plants for cleaning steel by any process—any engineer who decides to call for thorough cleaning must expect to pay an additional sum for such work, which, if the work be of small extent, will be disproportionately great in comparison with the work actually done; but if the work be of great extent the incidental cost of the plant will make but a small item in the total cost. Plants have been installed since the publication of the first edition of these specifications by several of the railroad companies for cleaning bridges in place, by some municipal engineers and by some manufacturing works where structural steel is treated. It has been objected that this is a patented process; it is therefore in order to observe that the original patent, under which work of great extent was carried on most successfully for fifteen years, was issued to General Benjamin G. Tilghman, of Philadelphia, on October 18, 1870, being No. 103,408, and has therefore expired long ago.

SPECIFICATIONS FOR ORDINARY WORK.

Shortly before riveting, all such parts of surfaces as are to be brought permanently into contact, shall be thoroughly cleaned from dirt and rust, and from all scale which does not perfectly adhere to the metal, by the use of scrapers, chisels, and wire brushes; the latter alone shall not be considered sufficient.

The wire brush is an efficient means of getting rid of loose scale and dirt; but it is practically worthless for removing thick rust or anything which adheres closely. Much of such material may be removed by steel scrapers, but deeply corroded spots should be thoroughly cleaned out with a chisel, and then well brushed. These crevices are hereinafter to be inaccessible; and they are subject to the most dangerous corrosion, because rusting at such places impairs not only the strength, but also the stiffness of the structure—a matter of much importance. These joints therefore deserve more care than any other part.

From George E. Thackray, Structural Engineer, Cambria Steel Company:

I believe that you are mistaken in stating and believing that mill scale contains material which induces further corrosion, as it is quite a stable compound, and on steel which is finished at a medium temperature, leaving the scale well rolled in and adhering to the metal, this alone will protect the surface for a long time. Of course some steels contain loose or blistery scales which, for mechanical reasons, should be removed before painting, as otherwise they would fall off and carry the paint with them.

In this connection I quote below from a paper on the Methods of Testing the Protective Power of Paints Used on Metallic Structures, presented by Mr. E. Ebert to the International Association for Testing Materials, with which our Society is affiliated.

"The view previously entertained by many manufacturers that the formation of rust tended to promote further oxidation by chemical means and that therefore preparations of oxide of iron exercised a prejudicial effect, has as the result of extended experiment, been fully and completely disproved."

"Though the importance of cleaning has been pointed out it does not, however, follow that the iron surfaces must be absolutely bright. Experiments which were carried out in the years from 1892 to 1896, in order to ascertain what was the effect of cleaning, have proved that it is fully sufficient, in order to free the iron from all impurities, to go over it with a wire brush or scraper, or if need be to employ a hammer to knock off any adhering scale. The layer of oxide or rust which remains after this treatment does no harm and it is in fact serviceable, as the preparation adheres better to it than it would to a bright and polished iron surface."

As to sand-blasting, I agree with you that this is almost useless and impracticable, as I have seen sand-blasting done, exposing the metal surface, which was soon covered with a thick coat of rust before the painters could reach it, although both the sand-blasters and painters were working with expedition.

DISCUSSION.

THE CHAIRMAN (MR. G. B. HECKEL).—I think that the report shows some of the troubles that the Committee has had. It is a very broad subject, about which very little is known, and about which very much knowledge is desirable. I do not think the Committee expects to settle all the problems confronting manufacturers or consumers; but it does expect to obtain from these tests some very valuable information; and as far as possible the Committee is equalizing conditions and guarding results. As the report says, there will undoubtedly be criticism. The Committee may make mistakes; but as far as it is possible I feel sure it is going to avoid them. **The Chairman.**

MR. H. H. QUIMBY.—Has the Committee considered the possibility that some manufacturers may submit for test a very different quality of paint than that generally furnished by them to the public, and the consequent lack of value of the test, were manufacturers unwilling to have the Committee use samples obtained in the open market? I should like to ask, also, whether different kinds of oils are represented in the paints submitted for test; whether there are paints made with other oils than linseed? **Mr. Quimby.**

MR. S. S. VOORHEES.—In reply to the first question, in these tests it was impossible to get any paints except those submitted by the manufacturers themselves. We have attempted to govern the quality of their paint by the price at the present market condition. **Mr. Voorhees.**

In regard to the second question, the analysis will show what oil and what pigments were used in these paints. It is stated in the report that the analysis will be included in this work.

MR. QUIMBY.—I do not see how the question of price will determine the fact that the paints submitted for test are the paints that are sold to the public; in other words, whether the manufacturers will submit a special paint, different from what they ordinarily manufacture and what the public gets when it buys it. **Mr. Quimby.**

THE CHAIRMAN.—I think that this special work is intended to be but the beginning of a series of similar tests made by this **The Chairman.**

The Chairman. Committee; and in the present case, as I understand it, the Committee, in order to make a start, opened this test to the manufacturers and allowed them to furnish paints. In connection with these paints, I believe, the makers give the prices at which they are willing to supply duplicate paints under present market conditions. As I understand it, the Committee intends to carry this further and to do independent work along this same line with paints bought in the open market. It is the general understanding, I believe, that the work of the Committee is by no means completed with this test.

Mr. Thompson. MR. G. W. THOMPSON.—Without speaking for the Committee, of course, I would mention that some of these points have been discussed at various meetings of the Committee; and while it was exceedingly desirable that information should be given on a purely scientific basis, the Society had no funds at its disposal to conduct such a purely scientific examination of paints. The best they could do was to get the manufacturers to supply the paints and supply the money to put them on; and they hoped that by the classification of the paints they could report the results independent of the manufacturers. In other words, the purpose is not to give any manufacturer any commercial preeminence, as I understand it. It may result, on inspection, in the discovery that certain paints have stood well in their respective treatment; and we want all the information that can be gotten in regard to those paints and in regard to the paints that stand well; and yet the manufacturer himself must be separated, to a certain extent, from the paint. We do not know of any other way in which the manufacturer can be protected, and yet, at the same time, a definite amount of benefit given him. If a certain paint happens to turn out well, it does not seem altogether right (even though the manufacturer has supplied the paint and money) that this should be used for advertising the product of that particular manufacturer; and, as I understand it, the Committee—the Special Committee that Mr. Voorhees has referred to—is to take up, and the whole Committee is to take up, the question as to the extent to which the results of these tests will be made public.

If we find that certain carbon paints give certain results, certain oxide paints give certain results and certain lead paints give certain results, we can tabulate the results in connection with

the classification of the paints. Whether much more than that can be done is a question the Committee will have to work out. We have made a start by getting these paints applied under favorable conditions; afterwards we shall have to study means of making the report. We have undertaken a pretty big proposition; and the thing that we must congratulate ourselves upon is that so many manufacturers have been willing to supply the materials. Mr. Thompson.

MR. VOORHEES.—I am very glad, indeed, that a paint manufacturer should speak from his standpoint. It is not the intention of this Committee to recommend any specific brand of paint. Whether the material offered is a standard paint or a special paint made for us, is a question which has received our consideration; and we appreciate that our tests may not be as perfect as they might be on that account; but in this present instance there was no way to avoid it; and, as stated in the report, it is hoped that this will prove a starting point for other series of tests on other types of structure along different lines of attack. Mr. Voorhees.

MR. A. B. HARRISON.—I should like to ask whether the results obtained on time tests on this bridge at Havre de Grace are to be published by this Society. Personally, as one of the contestants, I should like the results of this very interesting test published in full, giving the scientific world at large the benefit of the information obtained as to the efficiency of the various paints and coatings. Mr. Harrison.

MR. VOORHEES.—The intention of the Committee is to report on classes of paint. That was our idea in the rather searching questions regarding composition. We were in hopes that we would get data from the manufacturers, enabling us to classify the paints and put them where they belong. Now we will have to depend on our analysis. In most cases we will be able to classify them exactly; in some instances the analysis may not give us full information. Mr. Voorhees.

MR. KNOWLES.—I should like to ask, if the method of cleaning by sand-blast is considered a failure; whether it is thought too expensive or too unwieldy? Mr. Knowles.

MR. VOORHEES.—It was the original intention that half of some of the panels should be thoroughly cleaned to clean bright metal by the sand-blast, and the other half cleaned in the ordinary manner with chisel and wire brush. Mr. Voorhees.

Mr. Voorhees. The same paint was to be applied to each half. From the result of these tests it was hoped that data could be obtained relative to the economic value of the two types of cleaning, but unfortunately sand-blasting was not practicable in this test and it was dropped.

We have the comparison, however, between the panels painted on perfectly clean surfaces, the paint applied under most perfect conditions by skilled painters, and the bridge. The painting of these panels themselves is a work which requires a great deal of thought and expense as it requires a weighed amount of paint applied to a fixed surface. We shall have, from these panels, the effect of three known amounts of paint on a given surface. The oil paints will be spread at the rate of 600, 900 and 1,200 sq. ft. per gallon on perfectly clean surfaces. These will be exposed alongside of the bridge panels which have been prepared as stated.

Mr. Knowles. **MR. KNOWLES.**—How are the auxiliary plates which are to be perfectly clean prepared?

Mr. Voorhees. **MR. VOORHEES.**—They are pickled in 10 per cent. sulphuric acid, neutralized in carbonate of soda, washed in running water, packed in lime until ready to be painted, the excess of lime washed off, dried at a temperature of about 212° Fahr. or higher just before the paint is applied.

Mr. de Wyrall. **MR. CYRIL DE WYRALL.**—I am glad to see the Committee has done away with the expense of sand-blasting. In my experience in sand-blasting along the line of the subway in New York, we went to the expense of thousands of dollars to sand-blast columns. We placed them side by side with others that were cleaned in the least expensive way, by hammers, scrapers and wire brushes, and on exposure from one to four or five years, we find not the slightest difference in effect as between sand-blasting and the cleaning by hammers and chisels. There is just as much corrosion in the one case as in the other.

Mr. Voorhees. **MR. VOORHEES.**—Do I understand the paint was applied immediately after sand-blasting? I should say, in that connection, that a perfectly clean surface is very susceptible to corrosion. The corrosion begins immediately, as we find, in our panels. These panels are pickled and neutralized in soda and kept in lime until the paint is to be applied, and the same thing is true of a surface

which has been sand-blasted: the clean metal is very rapidly corroded. **Mr. Voorhees.**

MR. DE WYRALL.—We sand-blasted some, under the best conditions, that is under a shed; but even then we found that from the time that the man could get his brush in the pot and put the paint on, hygroscopic moisture had formed in sufficient quantity to start corrosion, which continued to form under the paint composed of red lead and linseed oil. Then we had a sand-blast at work in the subway and had the painters follow right up as quickly as they could; but the result was the same. In fact, I believe, some of the columns that were sand-blasted corroded sooner and more rapidly, and continued to do so from the time they were put in until we cleaned them off. **Mr. de Wyrall.**

MR. VOORHEES.—This is a very important matter, and we need more information on this question of sand-blasting. The paint manufacturer claims that the failure of the paint is due in many cases to imperfectly cleaned surfaces. The engineer desires to know how much money he is warranted in spending on cleaning the surface. Any information on this point is of great value. Undoubtedly, a properly cleaned surface will give better protection from paint applied. But is the cost warranted? That is the point. **Mr. Voorhees.**

MR. HARRISON.—As a paint manufacturer, I have given up all hope of having surfaces properly prepared and painted. Let us do the best we can under the conditions as they prevail, and not as we should like to have them or as they ought to be. Put the paint on in the way it is usually done, not in the way in which it can be done or in the way we want the painters to do it. It seems to me that the efficiency of a coating can be determined very much more accurately in such a test than when the surface is especially prepared under especially favorable conditions. For instance, coat a surface that has not been properly cleaned and which is rusty, then let the paint stand or fall by competitive results as to efficiency. Also, coat the surface of iron when there is humidity and dampness, even wet iron, and note comparative results with different coatings. It seems to me that information secured by this Society under such conditions, which we all know are prevalent, would be of especial interest. **Mr. Harrison.**

MR. DE WYRALL.—I am sure, from observation I have made **Mr. de Wyrall.**

Mr. de Wyrall. in the last sixteen years, that if we could get a coating or a pigment that would form a perfect vacuum it would not be necessary to clean the steel at all. On our 177th Street Station the steel contractor, the Assistant Engineer for the Rapid Transit Commission, and myself made certain observations and diagrams of parts of the structure that had not been cleaned in any way. We cleaned the balance as well as we could under existing conditions. That was about eighteen months ago, and the work was done in the dead of winter when it was too cold to do almost any kind of work. On examining the places where the rust had started before painting, we found on scraping off the coating that the pigments that we used had formed such a perfect vacuum that the corrosion had not spread. I also tried this in the subway three and a half years ago with the same result; but of course there must be a vacuum: corrosion cannot take place in a vacuum. The real problem is to make the paint suit the conditions, not in making the conditions suit the paint; which cannot be done.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

The series of paint tests planned last year and described in the last annual report of this Committee have been started. Nineteen different paints have been applied to 600 feet of the double-track deck bridge erected by the Pennsylvania Railroad over the Susquehanna River at Havre de Grace.

The record of time of cleaning, time of painting, with weather conditions, condition of paint, time of drying, condition of surface, manner of application and area of surface covered, have been tabulated and are under consideration. Analysis of the paint is being made.

The Sub-Committee on Method of Inspection after painting, has presented the following report. This method, subject to such modifications as are found necessary, will be followed.

METHOD OF INSPECTION OF CONDITION OF PAINTS UPON HAVRE DE GRACE BRIDGE.

(1) Inspection to be made every six months, unless for sufficient reasons the Committee desires more frequent inspections, by an official inspector. Notice of each inspection to be sent out previously to every member of the Committee with the endeavor to have the Committee represented at each inspection.

(2) As far as practicable a photograph should be taken at each inspection by a thoroughly competent photographer, preferably the inspector, care being taken to obtain negatives capable of enlargement and microscopic examination. A scale should be photographed in connection with the object.

(3) Character of gloss, to be noted by the inspector, whether high, moderate, dull or flat.

(4) Relative absorptive condition of each film when moistened with water.

(5) Relative toughness to be determined by cutting the film with a sharp knife, note being made whether elastic, tough,

brittle, or flaking, degree of adhesion being determined by the same test.

(6) Condition of surface to be noted, whether tendency to blister, alligator, scale, flake or powder (chalk), giving especial attention to the condition at angles and corners.

(7) Relative hardness to be determined by testing the films as to resistance to an edge of a cube of lead, tin, aluminum and zinc, respectively. The details are now being worked out by Mr. Heckel, and report upon the method will be made shortly.

(8) Note to be made as to the degree to which dirt has become attached to the surface.

(9) Condition of the surface as to powdering and general appearance, wear and weathering.

(10) When pitting has begun, the size, number, form, character and location of the pimple should be carefully noted, and the proportional increase since last inspection.

(11) Date to be noted on which repainting becomes necessary.

(12) These instructions are intended merely as a general guide to the inspector who will be expected to make as complete observations as possible of all matters which appear to him to be worthy of report.

The first inspection was made June 14th, and the results will be reported later.

The specification for preparation of surface and application of paint, together with instructions to the Director of Tests directly in charge of this work, was found impractical under conditions existing on this bridge.

The specifications required that all parts of structure be cleaned free from mill scale, dirt, rust, etc., to clean bright steel. This was found impractical as some of the members were badly rusted, especially in inaccessible parts, as between eye bars on bottom chord and on the latticed members. In such places it was found impossible to thoroughly clean without delaying the work to such an extent as to cause criticism from the railroad. The specifications also required that all paint be applied by the standard round pound brush. This was also found impossible on latticed members and between eye bars on bottom chord, etc.

It was found that serious delay would have resulted from a rigid adherence to the original specifications.

On account of these conditions, and rather than delay the painting of the entire bridge, the following set of instructions were issued to the Director of Tests on July 30th, 1906:

(1) The surface of all accessible metal, in so far as is practicable, is to be cleaned in a workmanlike manner with putty and broad knives, scraper and wire brushes so that all loose or easily detachable mill scale, rust and dirt are removed, as well as loose shop coat or "black oil" (by "black oil" is meant linseed). Any *non-drying oil or grease* on accessible parts is to be removed with either benzine or a torch.

(2) Where the shop coat is firm, hard, and in good condition it is not necessary to remove it. This applies also to black oil.

(3) Field and shop rivets are to be wire brushed and where necessary, this is to be followed by the knife or scraper; the hammer is not to be used.

(4) It is understood that the inside of columns and such other members difficult of access are not to enter into the test, and that the above instructions for cleaning do not apply to them. They should, however, be cleaned in accordance with the ordinary methods of the contractor. The inspector is to make note of such members and include them in his report.

(5) Painting should follow cleaning immediately, and as many different paints are to be applied at the same time as the length and position of the scaffolds and expediency will permit.

(6) No paint shall be applied when the humidity is greater than 85 per cent.

(7) Since the net cost of all work is borne by the Committee, the inspector will see that the work is done with reasonable promptness and will endeavor to keep the cost down as much as possible, consistent with reasonable thoroughness.

(8) All directions contained in the previous letter of instructions not herein modified are to remain in force.

It is felt that with the complete record of conditions of surface and application of paint given in the tabulated record sheets the value of the test has been increased.

A comparison can now be made between parts of structure prepared in varying degrees of thoroughness, and also where the paint has been applied with the standard round pound brush, with the "man-helper," a whitewash brush on long handle, and with the sheep-skin swab.

These comparisons would of course have been impossible if the original specifications had been followed. If the record of all conditions, weather, surface, application, etc., are true and trustworthy (and of this there is no ground for question) there is no doubt but that this series of paint tests has covered more ground than was originally intended and will clear up, as the test progresses, many points more or less obscure.

The plate test, it is felt, will prove of much value. These plates, 2 x 3 ft., were thoroughly cleaned to bright steel, by immersion in dilute sulphuric acid, neutralized in sodium carbonate solution, washed in running water, dried and packed in lime till painted. The paint was applied by a most skilful painter, under the most favorable conditions, at a uniform rate of spreading. Nine panels, three for each spreading rate all exposed in a very substantial frame on the down stream side of the bridge along side of the section of the bridge where the same paint was applied. A wooden walk with handrail has been erected by the Pennsylvania Railroad, on the down stream side of the bridge which will facilitate the inspection.

This test covers nineteen different paints, manufactured by sixteen different firms and includes nearly all of the leading types of paint, red lead, carbon as graphites, lampblack and carbon-black, oxide of iron with varying amounts and classes of inert materials, zinc oxide, asphaltums and special pigments. The vehicle is linseed oil in the majority of cases.

The exact composition will of course be available when analysis is completed. It will include per cent. and composition of pigment, per cent. and character of oil with approximate amount and composition of driers, presence and character of gums, as far as possible, and per cent. and identification of volatile matter with physical condition of paint, fineness of pigment, etc.

The chemical analysis has, however, required so much work that it cannot be completed in time to form a part of this report.

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The total cost of the test has been somewhat more than was anticipated, and it is not possible to determine if the subscriptions from the paint manufacturers will be sufficient to cover all expenses till the balance sheet has been struck.

The Committee wishes to thank the Technological Branch of the Geological Survey and the Bureau of Standards for their co-operation and desire to aid in this investigation.

Respectfully submitted in behalf of Committee,

S. S. VOORHEES,
Chairman.

J. F. WALKER,
Secretary.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR IRON AND STEEL.

The work of the Committee has followed the lines presented in the last annual report in continuation of the service test on the Pennsylvania Railroad bridge over the Susquehanna River at Havre de Grace.

The analysis of the fifty-seven paints applied to the nineteen sections of the bridge has been completed. The results were obtained by two independent analysts, Mr. P. H. Walker and Mr. P. C. McIlhiney, two members of the Committee who were directly in charge of the work. Mr. Walker's report is embodied in Appendix I, and the results obtained by Mr. McIlhiney are presented in Appendix II to this report (Plates IV, V and VI). The analyses were conducted in a very thorough and complete manner and give a clear indication of the composition of the pigment. The results obtained on the volatile part of the vehicle also give satisfactory indications of the composition. The results obtained from the analysis of the fixed oils, however, fail to give as much information as is desired relative to the quality, and in some instances even the nature of the oil. The constants which are the basis of conclusions are so modified by the oxides in the japan and in some cases by combination with the pigment as to be nearly valueless. These points will be fully detailed in report on analysis of the paints.

The result of the last official inspection made in May, 1908, is given in the following report of the Chairman of the Sub-Committee on Inspection:

PHILADELPHIA, PA., June 1, 1908.

MR. S. S. VOORHEES,
Chairman, Committee E, American Society for Testing Materials,
Washington, D. C.

Dear Sir:—

Comparison of independent notes of inspection of Havre de Grace Bridge on May 4, shows that the large majority of the paints are, to date, affording fair protection. The films are generally hard, elastic and adhesive, but noticeably lacking in lustre or gloss, with the following marked exceptions:

Paint 1. The gloss is markedly high; other characteristics as generally noted.

Paint 2. The film is badly fissured and cracked when observed under a glass, indicating early disintegration.

Paint 10. Higher gloss than generally noted, though very slight in comparison with No. 1. The film is brittle and shows tendency to alligator.

Paint 14. The film is lustreless but hard and brittle; badly cracked, showing lower coat. This feature is very noticeable on the lower chord bars of the bridge and particularly on the north side.

Paint 15. The film is failing seriously in nearly all panels though less on No. 600 than on the others. The bridge proper shows unmistakable evidences of rust with marked failure of the coating.

The general remarks relative to panels are applicable to the bridge proper. When anything is noticeably different between panels and bridge, it is noted.

(Signed) W. A. AIKEN,
Chairman, Sub-Committee on Inspection.

As was anticipated, no marked differences are noted in the majority of cases. As was clearly indicated at the inspection a year ago, the only example of an asphaltum coating thinned with a petroleum volatile solvent has failed to a marked degree after eighteen months exposure. A carbon paint containing rosin in the oil has developed minute fissure cracks all over the surface. While it is by no means conclusive that this failure is due to the rosin, still it is well worthy of note, and will be the subject of further investigation.

An example of difference in expansion of a red lead under-coat and a carbon final-coat is shown in Panel 14. The carbon coat has cracked badly on the bridge proper in cobweb-like cracks showing the red of the under-coat. The same final-coat applied also as an under-coat has not failed in this manner.

It is also interesting to note that one of the pure red lead pigments in straight raw linseed oil shows unmistakable evidence of alligating.

High gloss and tenacious film is shown by Panel 1. In this case the pigment consists of oxide of iron, red lead, and a carbon black mixed with a varnish containing some gum and thinned with turpentine.

The other panels or sections, as stated in the report of the Sub-Committee, show in most cases a marked loss of gloss with

minor differences in hardness, tenacity, toughness, and elasticity of film. These differences are, however, too slight to warrant expressing an opinion at this time.

There is evidence of rusting, to a slight degree, on all sections of the bridge, due to mechanical injury. These spots have been accurately noted and will be carefully watched at subsequent inspection. In general, however, the paints are affording good protection and it will require longer exposure to differentiate in the majority of cases. Still, each year will eliminate one or more of the paints as showing marked signs of failure.

The report of the Director of Tests, who was personally in charge of the work, is attached as Appendix III to this report. It shows the method followed in cleaning the surface and applying the paint, and the method used to determine the amount of paint applied per unit of surface, together with the Director's personal observations relative to the test. This report will be of much value in conjunction with the detail sheets giving data on surface and application of paint to each section. It will also be used in connection with reports of inspection.

It is becoming more and more evident that some form of laboratory accelerated tests are required to give indications of the value of a preservative coating. Individual members of the Committee have given this subject most serious consideration.

It is felt that the problem should be attacked by investigating the causes of destruction, the function of both the pigment and the vehicle, and the changes occurring during oxidation. It will be of much value to make a micro-photograph of the film in the condition resulting from normal application to the surface. Also micro-photographs of thin smears of the pigment will show clearly the relative size of the pigment particles. It will also be necessary to measure, and if possible express in relative or even actual terms, the hardness, tensile strength, elasticity, permanent set, adhesion, permeability, etc., of the film both *in situ* and detached from the surface.

One great difficulty has been the preparation of the film suitable for comparison. So far it has been impossible to prepare films from different paints containing different percentages of pigment and vehicle, so that they will be of comparable thickness. As the properties mentioned are largely a function of the vehicle,

the results will not be comparable with varying amounts of pigment.

It is felt that valuable data can be obtained by comparison of the results after different conditions of exposure. Investigations of this character, to be of value, must be conducted in the most painstaking and time-consuming manner, and it has been impossible for any member of the Committee to devote to this investigation the necessary time. The importance of the subject is more than sufficient, however, to warrant continued investigation, and it is hoped that by the next annual meeting, your Committee can report some practical method of making laboratory accelerated tests.

The following letter was received from the Secretary of the Paint Manufacturers' Association:

PHILADELPHIA, October 26, 1907.

MR. S. S. VOORHEES,

Chairman, Committee E, American Society for Testing Materials,
Washington, D. C.

Dear Sir:—

Doubtless you are familiar with the paint tests undertaken at the request of the Bureau of Promotion and Development of the Paint Manufacturers' Association of the United States, by Professor E. F. Ladd, and the North Dakota Agricultural College, at Fargo.

At a meeting of this Bureau held in Chicago on October 24, 1907, it was decided to duplicate the North Dakota tests at various points in the country with a view to determining the modifying effects of different climates, etc. One station selected for these extra tests was Atlantic City, N. J., and it is proposed that Committee E shall accept the supervision of these tests in the same manner as the North Dakota tests were accepted by the Agricultural College of that state.

It is desired that the Atlantic City test shall begin as soon as possible, and certainly this fall. If Committee E will accept the proposition to supervise the tests, and to assume jurisdiction over them during their continuance, the Bureau of Promotion and Development will pay all expenses connected therewith, including the supplying of the paints, analyses, erection of the fence, application, etc. As the time is very short, prompt action is necessary. Therefore, will you kindly take the matter up at once with the various members of the Committee by mail and ascertain whether they are willing to accept the responsibility suggested. My vote, of course, is in the affirmative and I have already informed the Bureau that I think the Committee will be quite willing to do what is asked of them. I have also communicated with Mr. Robert Job, who, I believe, thinks very favorably of the proposition.

It is proposed to either rent a piece of ground at a proper situation for the fence, or to ask the Pennsylvania Railroad Company, who doubtless own a great deal of land in the vicinity of Atlantic City, to allow us to erect a fence somewhere on their property. I am writing Dr. Dudley personally regarding the matter, suggesting that he ascertain for me whether such a piece of ground can be secured.

(Signed) G. B. HECKEL,
Secretary.

This offer was very carefully considered by the members of the Committee. It was recognized that such a test was much needed. It was felt, however, that these tests should be planned, developed and controlled entirely by Committee E, if the Society was to be responsible for the result. This was not possible, as the Paint Manufacturers' Association had prepared the paint on the formulas determined by them and had them ground in the special oils and japans desired. It was finally decided by the majority of the Committee to accept the supervision of the application of the paints, and a sub-committee was appointed with the understanding that its chief duties were to see that the paints prepared by the Paint Manufacturers' Association were fairly applied and to give reports in its several subsequent inspections only as to the relative appearance of the various panels. The first report of this Sub-Committee is as follows:

MR. S. S. VOORHEES,
Chairman, Committee E, American Society for Testing Materials,
Washington, D. C.

Dear Sir:—

By your direction a sub-committee composed of the following: Messrs. Aiken, Heckel, Sabin, P. H. Walker, and Robert Job (Chairman), met December 27, at the offices of Booth, Garret and Blair, Philadelphia, to decide whether or not it was desirable that Committee E should undertake the inspection of the painting of test panels which were to be placed upon a test fence at Atlantic City by the Paint Manufacturers' Association of the United States. By vote of the Sub-Committee Mr. J. F. Walker was also appointed a member and elected Secretary, and the Chairman of Committee E was elected a member of the Sub-Committee, ex-officio.

At the meeting Mr. Heckel, Secretary of the Paint Manufacturers' Association, stated that its object was to duplicate the tests made by Commissioner Ladd upon the North Dakota fence, with the same formulas there used as well as others which the Association wishes to test. Atlantic City was chosen for the exposure in order to get severe condi-

tions due to moist salt air and sand blast action and uneven temperature ranges. Mr. Heckel also stated that the paints for test had already been prepared by the Paint Manufacturers' Association at different factories using linseed oil and driers there on hand. The oil in each case was commercially pure linseed oil.

The Sub-Committee was further advised that the painting was to be upon specially prepared and dried panels of white pine, yellow pine, and cypress, respectively, and that the painting and drying was to be in a room under even temperature in order to avoid the unfavorable winter weather conditions. All of the panels had been given a careful inspection for the Association by a professional lumber inspector, and the effort had been made to get all in as nearly as possible the same condition.

Each paint was to be known only by number, and the test was to be not at all a contest of manufacturers, but was merely to determine any characteristic differences between the different formulas under the special exposure conditions.

It was the wish of the Association that the work of inspection be undertaken by Committee E in order that no question might arise regarding the perfect fairness in the application of the paints.

The fence was to extend north and south. Duplicate panels were to be placed upon each side of the fence, each paint was to be applied to panels of each of the above mentioned woods, and in the painting the weight of the paint applied to each panel was to be carefully determined.

All expenses incurred by Committee E in the inspection would be paid by the Association, including the expenses of the members of the Sub-Committee in attending meetings and inspection trips duly called by the Chairman.

The Association agreed to furnish to Committee E the formula of each paint, with composition of both pigment and drier.

In the course of a thorough discussion of the subject by the Sub-Committee, it was pointed out that under the conditions named by the Paint Manufacturers' Association, Committee E could merely assume to see that the paints prepared by the Paint Manufacturers' Association were applied impartially, giving reports in subsequent inspections as to the relative appearance of the panels. No responsibility could be taken regarding the composition of formulas, nor would the Committee be in position to draw conclusions officially from the results of the exposure.

On this understanding it was voted to accept for Committee E the inspection of the painting, and to recommend to the Chairman of Committee E the appointment of a sub-committee to take charge of the work. A report was made to this effect, and the Chairman of Committee E appointed the same sub-committee to take charge of the matter. Mr. J. H. Parthree of the Wilmington shops of the Pennsylvania Railroad was appointed by the Sub-Committee as its official inspector to be on hand during the entire progress of the painting to see that the work was carried out in a thoroughly impartial manner, and to take the weight of the paint applied to each panel. Mr. Parthree has certified that their conditions

were faithfully maintained throughout the work, and the statement of the weight of paint applied at each coat upon each panel is in the hands of the Sub-Committee.

Three coats were applied to each panel at intervals of about two weeks between each coat, and the panels were finally placed in position on the fence.

A general committee meeting was held at the offices of Booth, Garrett and Blair on January 31, 1908, and one inspection trip was made by the Sub-Committee on May 5; another is planned during the progress of the annual meeting of this Society in June and others thereafter, as often as may seem desirable to the Sub-Committee. It is hoped that in the course of the annual meeting, the fence will be visited by the members of Committee E and by all who are interested in the test.

The formula and composition for each panel, with key, has been furnished each member of the Sub-Committee, and one of the cans of each paint and each japan used, is in charge of the Chairman, in case checking any analysis should seem desirable. Also, to facilitate the work of inspection, blanks have been printed, as per sample herewith, to be filled out by each member of the Sub-Committee for each panel, at each inspection trip.

At the request of the Sub-Committee, the Paint Manufacturers' Association will also institute a series of check tests in which the white-paint base of each formula used will be applied in triplicate at three different rates of spreading, using the same oil and the same thinner in each case.

Also, after the exposure tests are finished, the most durable formula is to be taken, the drier varied, and exposures made.

A report has recently been printed by the Scientific Section of the Paint Manufacturers' Association, giving a detailed statement regarding the test fence. In that report an inaccurate statement appeared regarding the connection of Committee E with the tests. The matter was brought to the attention of the Paint Manufacturers' Association at our inspection trip on May 5, and a corrected statement to accord with our present report was prepared and given to the Association, which agreed to publish it in the form of a slip to be sent to every person to whom their report had been sent. In the future any statement issued by the Paint Manufacturers' Association concerning the work of Committee E will first be submitted to the Sub-Committee for approval. In this manner it will be possible to avoid inaccuracies.

The Sub-Committee believes that valuable indications will be given through this work of the Paint Manufacturers' Association, and it is hoped that at a future time Committee E may be in position financially to supervise throughout a similar test in order that the entire operation including the preparation of the paints, and all details, may be wholly under control which will be recognized everywhere as thoroughly disinterested, as well as scientific.

(Signed) ROBERT JOB,
Chairman.

The report of this Sub-Committee clearly defines the position of Committee E in this series of tests. Committee E's supervision extends only to seeing that these paints are applied in a fair and impartial manner following the method adopted by Prof. Ladd in the North Dakota series of tests, and includes the inspection of the panels at the subsequent inspections.

As the Committee did not determine the formulas on which the paints were made, nor follow the manufacture of these paints, our responsibility covers only the application and subsequent inspection.

A set of tests similar to the series started at Atlantic City is being carried on at Pittsburg. The results from these two separate investigations, together with the results now being obtained from the test fence erected by the Paint Manufacturers' Association at Fargo, North Dakota, will undoubtedly give this Committee some very valuable indications for further investigation along these lines.

Respectfully submitted on behalf of the Committee,

S. S. VOORHEES,
Chairman.

J. F. WALKER,
Secretary.

APPENDIX I.

PAINT ANALYSIS.

BY PERCY H. WALKER.

The series of paints with which this paper deals were all intended as protective paints for iron and steel. The samples were delivered at the laboratory in three lots, the first lot, Nos. C 3476 to C 3492, inclusive, were received May 8, 1907. The second lot, Nos. 3677 to 3697, inclusive, were received August 7, 1907, and the third lot, Nos. 3913 to 3932, inclusive, were received November 2, 1907. Labels on the cans indicated that the samples were all drawn between the middle of August and the middle of October, 1906. The first lot was completed August 10, 1907, the second lot, October 2, 1907, and the third lot January 10, 1908. About seventeen months, therefore, elapsed from the time of taking the sample until the completion of the analyses.

The samples as received were in quart Mason jars and as a rule were in apparently good condition. The jars were handled with as little shaking as possible and notes were made as to condition when received. The jars with their contents were weighed and when possible, the clear vehicle was drawn off. The jars were then again weighed, the contents transferred to other vessels, the jars wiped out and again weighed. These weighings gave the data necessary to figure the original contents of the jars.

The methods of analysis were in the main alike in all three series, but some modifications were suggested as the work progressed, and the methods used in the second series were more satisfactory than those used in the first, and those used in the third series were better than those used in the second. In the tables, Plates I, II and III, "(a)" gives the description of the samples as received in the laboratory, and the percentages of vehicle and pigment. These were determined by treating a portion of the well mixed residue left after drawing off as much as possible of the vehicle, with solvents. A continuous extraction apparatus was not used but the pastes in amounts varying from 7 to 75 grams were shaken with the sol-

vents, allowed to settle, the solvent decanted and the residue shaken with a fresh portion of the solvent. At first four portions of about 250 c.c. each of 88° gasoline were used to extract the vehicle. Samples 3476-84-85-86-87-88-89-90-91 and 92 were treated with this solvent alone. The other samples were treated with gasoline as above and then washed once with benzol and once with ether. Attempts were made to extract first with ether but the pigment does not settle and it is generally better to begin with gasoline and then use benzol and ether. With gasoline the first settling usually takes about twelve hours, the subsequent settlings being more rapid, usually less than two hours when using gasoline, but settling with other solvents always takes more time than with gasoline. Samples 3481, 3484, 3485 3683, 3684, 3685, 3692, 3693 and 3694 were not sufficiently settled to draw off any vehicle. The samples were thoroughly mixed and samples taken for the extraction. Nos. 3683, 3684, and 3685 were all liquid; the others all contained pigment in amounts varying from 10.9 per cent. to 77.9 per cent. Samples 3922 and 3926 were dry colors.

Where separation was possible the amounts of vehicle secured varied from 45 to 363 grams. In some cases this was clear, and in others more or less cloudy. In the first series volatile oils were determined by simply distilling amounts varying from 41 to 108 grams. The apparatus used was a 200 c.c. Jena glass Erlenmeyer flask which was connected with a vertical condenser by a tube bent twice at right angles, all connections being made of cork. The Erlenmeyer flask was suspended in a small air bath carrying a thermometer and heated by a Bunsen burner. The distillation was carried on until no further liquid came over when the thermometer in the air bath registered 190° C. The volatile liquid was caught in a small weighed separatory funnel which was held on the bottom of the condenser by a cork having a small notch cut in it to act as a vent. The volatile liquid in the separatory funnel was weighed and allowed to settle clear, the small amount of water was then drawn off and the funnel was again weighed. The remaining volatile oil was subjected to the tests indicated in the tables. In calculating the percentage of mineral oil from the unpolymerized residue it was assumed that 6 c.c. of pure turpentine would show not more than 0.2 c.c. of unpolymerized residue. These percentages are, of course, only rough approximations.

PLATE I.
 PROC. AM. SOC. TEST. MATS.
 VOLUME VIII.
 REPORT OF COMMITTEE E.
 APPENDIX I.—P. H. WALKER.

ANALYSES OF PIGMENTS.

MgO.	(AlFe) ₂ O ₃ .	ZnO.	Pb ₂ O ₄ .	PbSO ₄ .	White lead.	SO ₂ .	Serial No.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	
Trace	73.23	.....	9.67	.....	.....	1.46	C3476
None	54.94	None	6.48	.....	.....	.....	C3477
Trace	6.55	None	None	None	None	None	C3478
None	6.22	None	None	None	None	None	C3479
None	6.17	None	None	None	None	None	C3480
None	.37	None	None	None	None	None	C3481
None	3.35	32.25	None	18.37	27.01	None	C3482
.....	35.62	2.67	.....	.....	.....	31.25	C3483
0.15	.46	.....	6.92	.....	.....	.....	C3484
Trace	.28	.....	5.90	.....	.....	Trace	C3485
.24	.34	.....	7.31	.....	.....	Trace	C3486
Trace	.46	.....	26.84	.....	.....	Decided	C3487
Trace	.42	.....	27.45	.....	.....	Trace	C3488
Trace	.36	.....	27.81	.....	.....	Trace	C3489
.87	2.48	.....	65.12	.....	.....	.43	C3490
.70	2.39	.....	56.20	.....	.....	.42	C3491
Trace	3.41	.....	2.80	.....	.....	.57	C3492

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes that proper record-keeping is essential for transparency and accountability, particularly in financial matters. The text suggests that organizations should implement robust systems to track every aspect of their operations, from procurement to sales.

2. In the second section, the author addresses the challenges faced by small businesses in managing their finances. It highlights the lack of access to capital and the difficulty of securing loans as major obstacles. The text advises entrepreneurs to develop a strong business plan and maintain a good credit history to improve their chances of obtaining financing.

3. The third part of the document focuses on the role of technology in modern business operations. It discusses how digital tools can streamline processes, reduce costs, and enhance productivity. The author encourages businesses to embrace innovation and invest in the latest technologies to stay competitive in the market.

4. The fourth section explores the importance of human resources in organizational success. It stresses that a skilled and motivated workforce is crucial for achieving long-term goals. The text provides recommendations for attracting top talent, including offering competitive salaries and benefits, as well as providing opportunities for professional development and growth.

5. The fifth part of the document discusses the impact of market trends on business performance. It notes that businesses must stay informed about industry developments and be prepared to adapt to changing market conditions. The author suggests that companies should conduct regular market research and use the insights gained to inform their strategic decisions.

6. The sixth section addresses the issue of risk management. It explains that identifying and mitigating potential risks is a critical component of any business strategy. The text offers practical advice on how to assess risks and implement effective risk management practices to protect the organization's assets and reputation.

7. The seventh part of the document focuses on the importance of customer satisfaction. It states that providing excellent customer service is a key factor in building a loyal customer base and driving business growth. The author recommends that businesses should listen to customer feedback and make continuous improvements to their products and services.

8. The eighth section discusses the role of marketing in business success. It emphasizes that a well-executed marketing strategy is essential for reaching target audiences and promoting the organization's offerings. The text provides tips on how to develop effective marketing campaigns and measure their impact.

9. The ninth part of the document addresses the issue of legal compliance. It stresses that businesses must adhere to all applicable laws and regulations to avoid legal penalties and reputational damage. The author suggests that companies should consult with legal counsel to ensure they are fully compliant with all relevant laws.

10. The final section of the document provides a summary of the key points discussed and offers concluding thoughts on the importance of a holistic business approach. The author encourages businesses to take a comprehensive view of their operations, considering all aspects from finance to marketing, to achieve sustainable growth and success.

At first the plan used in the first series was followed in the second series, but it was found that though fairly good results were obtained when the vehicle contained large amounts of volatile oils, very bad results were obtained where little volatile oil was present. This throws a good deal of doubt on the percentage of volatile oils in the first series, the figures being probably low. The method then followed was to distil about 25 grams in a current of live steam, using a 500 c.c. round-bottom flask with a spray trap between the flask and condenser. Distillation was continued until 100 c.c. of water had passed over. The oils were then separated from water and weighed and 0.3 gram added, a correction arbitrarily chosen for the oil dissolved in the water. The testing of the volatile oils was done on the mixed oils obtained from dry and steam distillation, using, of course, different portions of the vehicle; but in examining the non-volatile portion, the residue from the dry distillation alone was used. In this series there are six samples which had not settled; in these the volatile oil was determined by steam distillation.

In the third series the determination of volatile and non-volatile in the vehicles was effected by a method which is better than any used in the first two series. Amounts varying from 27 to 79 grams were weighed into a 500 c.c. round-bottom flask connected with a condenser by means of a spray trap. A current of live steam was passed through until 100 c.c. water collected in the receiver the oils were separated from water, weighed, and the same correction (0.3g.) applied as in the other steam-distillation method. After driving off the volatile oils the steam was cut off and air drawn through. At the same time the flask was heated to 130° C. In about 15 minutes all water was driven off and the residue was used for testing the non-volatile portion. Only three samples (3930-31-32) of the third series were subjected to dry distillation, and these were so treated in attempting to determine acetone, which, while it was indicated by shaking the paint with water and getting the iodoform test on the watery solution, could not be quantitatively determined, since no distillate could be recovered even on heating to 190° C.

The tables of analyses show clearly what was done with the non-volatile portion of the vehicle. In the first series saponification numbers were determined on several of the samples. In the last

two series this was not done, but the unsaponifiable matter was determined instead.

In the analyses of the pigments in the first series the samples were treated with hydrochloric acid (1:1), filtered on a weighed paper, dried at 105° C., and weighed. The residue was then ignited and again weighed. The loss on ignition was called carbonaceous matter.

In the second and third series a different plan was followed. One portion was weighed out and the loss at 105° C. determined. This was then ignited and again weighed. The second loss would be combined water, carbonaceous matter, CO₂, etc. Another portion was treated with hydrochloric acid, filtered on a Gooch crucible, dried at 105° C. and weighed. This was then ignited and the loss was called "carbonaceous matter." This subtracted from the total loss gives the "loss on ignition less carbonaceous matter weighed as such."

The rest of the results were obtained in the ordinary way. In the first and second series the lead was assumed to be as red lead and calculated as Pb₃O₄ except in No. 3483 where it is calculated as lead sulphate and white lead, the sulphate being figured from the SO₃ found, and the remaining lead calculated as basic carbonate, a qualitative test showing CO₂.

In the third series, Nos. 3913 to 3921, inclusive, the lead is calculated as PbO. In Nos. 3922 to 3932, inclusive, lead is calculated as Pb₃O₄. On the red lead paints, Nos. 3922 to 3929, inclusive, in addition to determination of total lead, which for the summation was calculated as Pb₃O₄, the amount of actual Pb₃O₄ was determined by titration of iodine liberated from KI by the pigment in the presence of large excesses of sodium acetate.

It must be confessed that these analyses do not give the information desired. We can with reasonable certainty decide whether the volatile oil used was turpentine or mineral oil, we can come to a fairly good conclusion as to the composition of the pigment, though even here we are frequently left in the dark. For example, we cannot say whether the magnesium silicate found was of an abestos or talc nature. These, however, might possibly be determined by the microscope. On the whole, for determining the general nature of the inorganic pigments and the volatile oils used, chemical analysis is fairly satisfactory. The carbonaceous

matter present, however, may be due to carbonaceous matter in the original pigment or it may be due to unextracted vehicle. In No. C 3476 the pigment was red. It appeared to have no carbon, but the analysis shows 10.44 per cent. carbonaceous matter. In this case this carbonaceous matter was due to unextracted vehicle (gasoline only was used in washing out the vehicle). Now what was the nature of this unextracted vehicle? Was it linoxyn? From the fact that we have nearly 10 per cent. of red lead present and the remainder is nearly all oxide of iron it is certainly possible. Was it gum? A varnish instead of a straight oil might have been used. From the information available concerning this sample we learn that the last hypothesis is probably the correct one; but it must be confessed that from the chemical data alone we really cannot decide. If we take the cases, however, of the dark colored pigments where some carbonaceous matter is evidently present in the pigment, we certainly cannot say that all of the carbonaceous matter found was derived from the original pigment. While as has been shown the interpretation of the analyses of extracted pigments often presents great difficulty, the interpretation of the analyses of the non-volatile portion of the vehicle is much worse. I must confess that an attempt to draw any conclusions from these analyses is very discouraging, in spite of the large amount of work done. Perhaps it would have been better had we subjected all samples to an analysis adapted to varnishes with the idea of determining the gums present. Such analyses are at best unsatisfactory and we were also of the opinion that most of the samples would at any rate be straight oil paints. The specific gravities of the total vehicle and, in the last series, of the non-volatile portions were determined with a pyknometer. This was a mistake. A Westphal balance should have been used and would have practically eliminated the error due in some cases to the small amount of pigment which did not settle out. In some cases these analyses can be interpreted as indicating pure linseed oil, as, for example, No. C 3483; but in other cases this cannot be done. Consider No. 3482. From the ash, saponification number and specific gravity (which by allowing for the 18 per cent. of light oil found in the vehicle would be about 0.935 for the non-volatile vehicle) would indicate pure linseed oil; but the iodine number is low. We know though that on mixing with lead compounds the iodine

number of linseed oil is sometimes lowered very much. We also know that some linseed oils have a specific gravity above 0.935. Now is this a pure linseed oil which has had its iodine number lowered by being in contact with lead carbonate and sulphate, or is it a mixture of linseed oil with other fatty oil? I must confess I cannot say.

This paper is presented with a hope that it will lead to a discussion of the interpretation of paint analysis. I wish to express my thanks to the Assistant Chemists in the Contracts Laboratory, Messrs. F. W. Smither, H. C. McNeil, and E. W. Boughton, for their skilful and careful work in completing this long series of very complex analyses. These gentlemen did all the analytical work.

PLATE IV.
 PROC. AM. SOC. TEST. MATS.
 VOLUME VIII.
 REPORT OF COMMITTEE E.
 APPENDIX II.—P. C. McILHINEY.

Panel No.	Coat No.	Per cent. of Pigment.	Per cent. of Oil.	Per cent. Volatile.	White Lead, per cent.	VEHICLE.			
						Figure	Volatile.		
							On Saponifiable Oils.	Flash at 30° C.	Refractive Index at 20° C.	Remarks.
1	1	36.8	46.5	16.7	....	155.9	No	1.4663	Turps.
1	2	20.8	64.8	15.4	....	....	"	1.4641	"
2	1	33.5	55.6	10.9	....	....	Yes	1.4164	Turps. and benzine.
2	2	39.9	51.4	8.7	....	....	"	1.4142	" "
2	3	36.9	53.7	9.4	....	....	"	1.4171	" "
3	1	6.9	46.5	46.6	....	....	No	1.4653	Turps.
3	2	62.5	28.1	9.4	30.43	....	Yes	1.4470	Turps. and benzine.
3	3	48.3	49.3	2.4	....	....	No	1.4590	Turps.
4	1	14.0	60.1	25.7	....	....	"	1.4652	"
4	2	7.9	71.2	20.9	....	....	"	1.4650	"
4	3	15.2	59.6	25.2	....	....	"	1.4653	"
5	1	52.0	44.2	3.8	....	....	Yes	1.4527	Turps., benzine and camph. oil
5	2	47.5	45.6	6.9	....	....	"	1.4465	" " "
5	3	50.7	46.7	2.6	....	....	"	1.4482	" " "
6	1	61.1	35.7	3.2	....	71	No	1.4191	Turps. and benzine.
6	2	60.2	34.9	4.9	....	....	....	....	"
6	3	34.0	57.7	8.3	....	....	Yes	1.4593	Turps. and benzine.
7	1	52.6	42.5	4.9	....	....	"	1.4226	Turps., benzine and camph. oil
7	2	52.8	41.1	6.1	....	....	"	1.4263	" " "
7	3	52.8	41.7	5.5	....	....	"	1.4219	" " "

APPENDIX III.

SUPPLEMENTARY REPORT OF THE DIRECTOR OF TESTS.

The application of the paint was completed on October 15, 1906, and all data required by the Committee was submitted by the Director of Tests on a tabulated sheet for each separate manufacturer's protective coating. In answer to the Committee's request for descriptive notes as to conditions and incidents relating to the work, the following supplementary report is respectfully submitted:

The structure had been completed but a few months, and the painting was the first following the shop and erection coat. For the test the panels were numbered from west to east, making twenty panels for the two spans, and Panels 1 to 19 were used for the tests. Panel 20 was turned over to the contractor as his regular work, and his paint was applied on Panel 20 at the same time as that of the test on Panel 19. The division of the panels for the tests was so made that each of the 19 tests was applied to a full panel cross section of the bridge, but in order to give each test a full truss-post the dividing line was drawn half way between posts.

As the Committee required each test to be made with three coats, while some of the manufacturers asked for a test of two coats only, a compromise was made by painting the entire down stream half of the 19 panels, three coats, and allowing two coats *only* on the up stream half of such panels as the manufacturers requested.

For cleaning the arrangement of staging and men was as follows:

1. Two men, on planks that were extended from floor beam to floor beam, for cleaning the upper work between stringers and between top chords and stringers.
2. A four man staging was worked in each panel between floor beams from the top of floor beams down to the bottom horizontal bracings.
3. Two men on a plank suspended below the bottom chords from truss to truss, moving the plank forward as work progressed.
4. Two men on the outside of the top chord on a plank slung from the outside guard timbers.

The brush men followed on the same kind of stagings except that all the top work was painted from the four man, track suspended, staging. Unfortunately, this arrangement of stagings required the application of two different tests at the same time on the same four man staging, one from each end; and as the areas to be covered were not uniform, one end crew would have more surface to cover than the other. This, in a measure, makes void a comparison of time and areas covered, and furnished encouragement for a man to slight his work in trying to keep up with the other men.

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From the beginning of preparations in June, 1906, to September 1, 1906, when work had advanced as far as the cleaning of Panels 1 to 7, and the application of the first coat on Panels 1 to 6, Mr. F. H. Cubberly, from the Philadelphia Department of Bridges, was in charge as Director of Tests. His leave of absence expiring on September 1, the writer assumed the position, taking over the work and continuing it without interruption, except from weather conditions, until completed. The brush work on the bridge was completed October 15, 1906, and the triple sets of test plates were, on November 1 to 3, placed for exposure by fastening them securely in a strong framework that had been previously bolted on the top of the bottom chord of the down stream truss. Each coating-test plate was placed in a vertical position with a southeasterly exposure in its respective bridge-panel.

The Director, after September 1, did not find it necessary to delay the brush work and use the stagings for inspection, but was almost constantly with the men. For both cleaning and brush work he was able to point out errors as the work advanced, and the men were sent back or the staging changed at once to correct these errors. This practice, with the point gained by keeping each man on his particular part of the work, soon put the entire force in line, and while the work was not up to the Committee's anticipated point of theoretical execution, the result was above the average of that attained in general railroad bridge painting. Occasionally, paint was spilled on work partly dry or men used tools not as directed; some in hurrying to keep up with the other better man did not brush out their work well, especially where the mixture worked stiff and the experienced man was better able to do quick work well. In this connection it was demonstrated that a section painted with a stiff mixture appeared uneven and poorly done, when with a light easy flowing mixture a more even and better class of work could be done, regardless of any effort the Director might make to prevent bad work. The above is equally true with regard to the work of different men cleaning the steel.

Weather observations were recorded at the hours designated. If humidity conditions were close to the limit, frequent observations were taken. Sudden light showers would call for a halt on account of excessive humidity and if the reading returned to the safe limit but moisture could be found on the steel by a handkerchief test, work was delayed until no moisture remained. However, it must be admitted that applying paint on days when the humidity is close to the limit and on other days when the air is clear and dry is not a good procedure for comparative tests.

"In the course of application of each individual sample the Director shall obtain from the workmen general information as to the working qualities of the paint, as well as such other particulars as may suggest themselves to him as useful. In each instance he shall also note particularly the rate of drying and the physical appearance of each coat."*

Opinions expressed by the brush men were contradictory and condi-

* Instructions to the Director of Tests. See Vol. VI., p. 53.

tions were such that no attempt at a comparison of working qualities was made. This can best be taken from the notes of the plate test, made by the Committee's experts from the same paint that was being applied on the bridge.

Before the hour for starting work each morning the Director passed over the bridge and examined the steel for moisture or other irregular conditions. Then the weather records were taken and if conditions were right the foreman was signaled to come for paint. The paint was weighed out to the men in regular brush pots ready for use, marked with metal tags, the Director following the pots to their respective panels, and when work stopped or changed the pots and brushes were returned to the store-room and properly cleaned. Where round pound brushes could not be used flat lamb's-wool swabs were permitted and on the inside of bridge seat chairs and the inside of top chord box girders double round pound brushes on long handles were used.

"The painting of the check panels provided for the Committee shall be under the general supervision of a competent and expert painter but the Director shall make careful note of all details in regard thereto in connection with his notes on the general work."

The steel plates used were prepared as directed and were handled entirely by the expert painter and his assistant. The work of cleaning the plates was done in a shanty near the bridge and the paint applied in another room fitted up exclusively for this work. The paint store-room was a third shanty near the others and all were so arranged that the Director could know that the work was properly done without taking his attention from the bridge work.

The instructions from the Committee's letter of July 30, 1906, were carefully followed.

The steel was cleaned by the advance gang of six men on the stagings as previously noted. First a sharp-edged steel chisel, about 1½ ins. wide, and long enough to be used by both hands if desired, was used to remove everything loose. These chisels were kept sharp and did good execution. After the chisels a very stiff steel wire brush was used to remove the rough loose paint that was left behind the chisels and also to brighten up the rusty surfaces. As is usual in large bridges, the condition of the steel surface varied from a smooth, hard black-oil shop-coat finish on most of the beams and top-chord members to a rough sticky, heavily-coated black-paint surface on nearly all of the eye-bar members of the trusses. The eye bars had evidently been stacked up when the paint was wet and in separating them the paint had either peeled off in a few spots or the wood had adhered in a few places to the steel. Many of the eye-bar members, although painted months before, were (in warm weather) still sticky, and if rubbed with the stiff wire brushes became rough but could not be cleaned by any manipulation of the chisel or brush. Only fire or the sand blast would have cleaned the steel entirely of paint and rust. This condition was also true of a few of the 5-ft. floor beams. These

members were gone over with the sharp chisels only, and the first coat of our paint brushed on over the soft shop coat. In general the top and bottom surfaces of the small horizontal members had entirely lost the shop coat but the surface rust had not become rough from scales. The truss posts and some of the bottom chord members threw off scales of paint and rust under the chisels, showing plainly that the shop coat had been applied under bad conditions. Many of the built members showed a shop coat of black on the plates with red lead under the flange and stiffener angles. Red lead had also been freely used in erection, on the bridge seat chairs and pin connections. The top chord (box girder) had also received a good coating of red lead on the inside. Also, before tracklaying, the upper surface of all top members had been painted, according to the Company's standard requirements, with red lead paint and we were required to do no top surface work. Also, complying with the Committee's final instructions, the inside cleaning of box girders and posts was omitted. Bottom chord members were cleaned (where close together) only by such chisel work as was possible and these surfaces are not a part of the comparative test. The use of the long handle brushes in the top-chord box girders was very unsatisfactory. Much paint (of the light mixtures) was lost by dripping from the brush although some of the men were expert and did good work. After the first coat these surfaces were not painted and no long handle brushes were used as these members had been well painted inside before erection. These conditions are pointed out to indicate the obstacles which prevent uniform work on a structure of this class by the average gang of bridge painters in the regular course of work. We can, however, claim to have done as nearly uniform work and to have painted our part of the structure in as thorough a manner as can be expected under present-day conditions. In considering the different sections, it should be remembered that the tabulated data sheets show that the steel was not in a uniform condition. The amount of rust and scale increased towards the east, due undoubtedly to the fact that yard engines in switching came on the bridge from that end. Also, during the progress of our work construction trains loaded with ashes were switching on the east end and not infrequently showered a fresh coat with water or ashes. It was noticed that although no visible signs of grease had been observed before the first coat was applied, still on some sections after the first coat began to dry, there was unmistakable evidence that the inside of the track stringers directly under traffic, were spattered with grease, probably from passing trains or the jolt of an engine stopping on the bridge. This was observed on two sections and noted on the data sheets.

Weather conditions also prevented uniform results. In one instance, paint was applied on two adjoining sections until five o'clock p. m. under correct weather conditions, but a driving storm came on and while one paint held and was not considerably injured, another, a slow drying paint was badly washed and also injured the fresh paint of the adjoining panel by washing down upon it along the batter post and truss diagonals.

The Director endeavored to follow the Committee's written instructions so far as the average conditions and the skill of the workmen could be made to conform to them. If his interpretation was more practical than some of the members may have desired it must be remembered that only the inside work on the test plates was by skilled workmen and under conditions that were wholly within the Director's control.

From these plates all conditions of spreading and drying rates and nature and condition of film should be determined. After September 1, the contractor and his men gave the Director loyal support in the practical execution of the work, under the Committee's instructions, as they had at that time been interpreted, striving so far as possible, to make the work uniform and to give each coat the same handling, and at the same time to proceed with the job in a manner that could be considered consistent for general first-class work. The bridge work should be judged as a practical test that was attended with the usual accidents and incidents on such work, but with more than the usual care regarding weather conditions and correct brush work. The Director's inspection of the completed work indicated that panels painted with the light easy flowing mixtures were more evenly coated and gave evidence of better results than some of the heavier pigments which had what appeared to be a first class vehicle forming a stiff mixture hard to apply. It is equally true that the only trouble caused by the second or third coat breaking away when applied on very cold steel came from what appeared to be the highest-grade heavy-weight paints.

The data sheets give information as to conditions of steel and show the preparation of the surface to have been not the smooth surface free from the black-oil first coat, as had been the Committee's first expectation.

If the element of personal equation (good or bad work) could be eliminated from our field work, it might be profitable to note the comparison in service between the bridge work on a very bad steel surface and on that of the same paint on test plates being exposed to the same weather conditions. Conditions were such, however, that it is not possible to determine whether peculiar conditions of color, surface, texture or apparent brush marks that might be observed by a careful inspection of the bridge, are due to a failure of the mixture to fulfil the requirements of a good protective coat, or to the fact that this particular condition was caused by one of the many possible accidents or incidents noted in connection with the work. Speaking broadly, the experience of the Director impressed him with the belief that users and manufacturers of protective coatings cannot expect positive or uniform results in the field work while the present careless practice in applying shop coats continues, and that until a successful machine method of applying paints can be found to replace the present uncertain hand labor application, the best mixture will not always produce the best protection.

Respectfully submitted,

HOBERT B. POTTER,
Director of Tests.

THE INHIBITIVE POWER OF CERTAIN PIGMENTS ON THE CORROSION OF IRON AND STEEL.

BY ALLERTON S. CUSHMAN.

In the discussion following Mr. Hughes's paper on "Deleterious Ingredients in Paint," presented before the Society at the last annual meeting, Mr. G. W. Thompson described a method of testing pigments to determine their relative electrolytic activity in relation to iron. Mr. Thompson also suggested that Committee U investigate this matter to see whether it can be determined if certain pigments have an inhibitive action on corrosion.

Considering the subject from a theoretical point of view and without any previous knowledge, prejudice, or opinion concerning any pigment whatsoever, Mr. Thompson's suggestion appeared to me to offer an attractive field for investigation which might possibly lead to results of great value. In view of the fact that past researches had shown that the soluble chromates exert a pacifying and protective effect on the surface of iron and steel, I made the following statement in my address to the Society a year ago:

"It would appear that slightly soluble chromates should be theoretically the best protectives for the first application to iron and steel surfaces."

On further consideration of the subject, however, it occurred to me that, if the chrome pigments had been precipitated in an acid medium or contained either by admixture or contamination soluble electrolytes which stimulated corrosion, in the ensuing struggle the iron might fare worse than if no especial preventive measures had been attempted. In order to get some information in regard to this point, samples of bright steel wire were immersed in 100 c.c. of a very dilute $n/1000$ normal solution of bichromate in a series of shallow dishes. The wire test pieces were suspended in the solution so that they did not come into direct contact with the glass surface of the dishes. This precaution should never be omitted in experiments of this kind, as, owing to the absorption of air by glass, rusting is always stimulated at the point of contact between glass and iron. A dilute tenth-normal solution of copper

sulphate was now made up and used in the following manner: The first dish having been left as a blank, the second received one drop, equal to $\frac{1}{8}$ c.c. of copper sulphate solution. The third dish received two drops, and so on, each dish getting an increased amount of copper sulphate until twenty-five dishes had been prepared.

Now it is apparent that we have in this system two contending forces at work. Iron has a higher solution tension than copper and therefore tends to pass into solution, the copper tending to come out and deposit on the iron. Chromate ions on the other hand put the surface of iron in a condition in which it can not pass into solution. In the solution system iron-chromate-copper, we have an equilibrium to be decided between two contending forces acting in opposite directions. In view of this struggle which was known to be going on, although the actual conflict could not be watched, it was interesting and instructive to note the results. In the first dish, in which no copper was present, no corrosion took place, in the second also, no action was visible. In the third, however, minute specks of iron rust appeared. These were larger and more frequent in the immediately succeeding dishes, the test pieces showing rust tuberculation with the well known pitting effect. As the middle of the series of dishes was approached both iron rust and precipitated copper began to appear side by side on the surface of the iron and from there on in the series more and more copper separated, while less and less rust formed, until in the end dishes copper and iron were changing places evenly over the surface without apparent hindrance. These experiments and others of a similar nature were repeated many times with the same results and there seems to be no escape from at least the following two conclusions to which they obviously lead:

1. If the surface of iron is subjected to the action of two contending influences, one tending to stimulate corrosion and the other to inhibit it, the result will be a breaking down of the defensive action of the inhibitor at the weakest points, thus localizing the action and leading to pitting effects.
2. While the concentration of an inhibitor may be strong enough to prevent the electrolytic exchange between atom and ion, it must be still stronger to entirely prevent the solution of iron and the subsequent oxidation which leads to the formation of rust spots.

Applying these principles to the selection of inhibitive pigments it is apparent that many paints may contain substances well adapted for carrying on just such a struggle on the surface of iron. I take it for granted from the paint literature which I have studied that it is the consensus of opinion among experts that an ideal vehicle for spreading pigments does not exist. Linseed oil, well adapted as it is in some respects, not only undergoes complex changes but absorbs and carries water. Therefore, even when covered with the best paints the surface of iron is sooner or later subject to attack by the two factors which produce corrosion, viz., hydrogen ions and oxygen.

The method of testing proposed by Mr. Thompson can be used at least for dividing pigments into three main groups or classes: (1) those which stimulate corrosion, (2) those which are neutral, and (3) those which inhibit corrosion. The method of carrying on the test which we adopted was as follows:

A long train of bottles was arranged as is shown in Fig. 1, so that a blast of air could constantly be blown through under pressure.

A quantity of Bessemer steel sheet was obtained and used just as it came from the mill without preparation of the surface in any way. It was cut up into pieces of equal surface area, weighing about 4 grams. Into each bottle were placed two of these test pieces which had first been separately weighed to the nearest 0.0001 gram. 100 c.c. of laboratory distilled water was then added to each bottle, and equal parts by volume (10 c.c.) of the various dry pigments to be tested were added in succession to the bottles in the train. Blanks were inserted at the beginning, in the middle and at the end of the train. It was not considered necessary to determine the specific gravity of the pigments in order to get a precisely constant volume, as the roughness of the test renders such a refinement unnecessary, while the work and time required in such an undertaking would be tremendous where a large number of samples are to be tested. A small hollow brass cylinder with a handle soldered to it was used as a measure. This was heaped with the pigment, tapped three or four times and the mass smoothed off with the edge of a spatula. Thus in every bottle there was placed approximately the same volume of pigment.

The samples consisted of a collection of about fifty pigments

supplied by the Paint Manufacturers' Association of the United States, and represented the ordinary commercial pigments in common use. While the names and general composition of these samples were known to us, no effort was made to determine their degree of purity, or whether they contained soluble impurities which might stimulate corrosion. It was determined to let the test tell its own story, and then if necessary leave the interpretation to the future.

By means of the large pressure bottle at the beginning of the

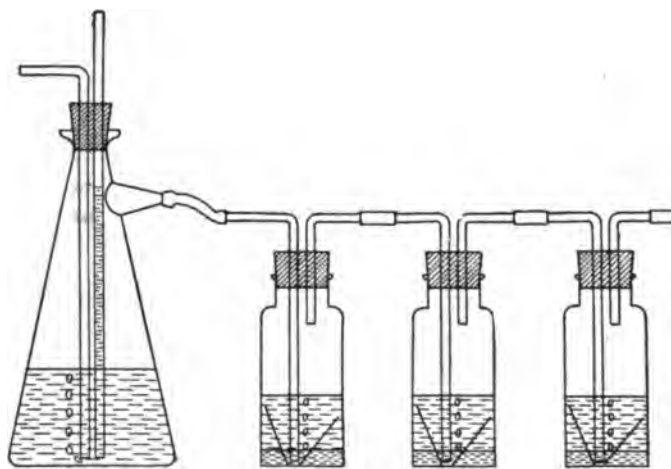


FIG. 1.—Thompson's Method of Testing the Inhibitive Value of Pigments.

train, a fairly constant rapid current of air was kept bubbling through.

The test was divided into three periods in the following manner: At the end of forty-two hours the samples were withdrawn, washed, brushed with a small nailbrush, dried, and weighed. They were then put back and the air blast turned on again for one week, after which they were again removed and weighed. Finally they were put back again, and the run continued two weeks longer. It would have been interesting to push the test still further, but lack of time and pressure of other work has not permitted this. The results obtained were plotted as actual

loss of weight, and were not calculated as per cent. of loss. Corrosion is entirely a function of the amount of surface exposed, and within the limits of the test has nothing to do with slight variations in the weight of the samples. The fact that each bottle contained two test pieces of equal area furnished a check on the work, and showed that the action going on was not haphazard. In every case the loss of weight of the twin samples was of the same order of magnitude, while in most cases the check was remarkably close. In plotting the results the total loss in the respective bottles was used.

The greatest perplexity which the results of this test engendered was to determine what use should be made of them. That they were instructive there seemed to be no doubt, but the fact that they appeared to condemn some types of pigments that have frequently been used and are highly thought of by many persons was somewhat alarming. Having in mind the fear that too hasty conclusions might be drawn which might prove harmful to certain interests, it was finally decided to reserve publication of all results until the work could be repeated by other investigators. More than fifty pigmentary substances were used and it was found that while the test pieces in some of the bottles were hardly touched, others were badly corroded and even pitted through. If we consider only the chrome pigments which were tested, it may be pointed out that a great difference exists in their inhibitive action. Some chrome compounds, among which zinc chromate is conspicuous, appear to be highly protective to steel in this test, whereas others show up as strong stimulators of corrosion. This variation in the action of pigments of the same general type is doubtless due to the presence of stimulative impurities. A test such as the one described, which will enable investigators to separate pigments into different classes as far as the resistance to corrosion which they offer, will therefore be of great value.

In conclusion let me call attention to a peculiar phenomenon which has been observed while carrying out these tests, and which I have discussed in a paper on "Electrolysis and Corrosion." In order to distinguish the two samples in each bottle from each other one was marked with a small dot which was prick-punched on the steel surface. In the cases in which the corrosion had gone far these small indentations were eaten through to pit holes.

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This seems to show that if it is a matter of importance to avoid pitting, care should be taken to select steel which is as free as possible from indentations, scars, or wounds of any kind. Although it is not claimed that a true surface will not suffer at all, it is none the less true that each indented point will become the location of a destructive pit hole.

REPORT OF COMMITTEE E ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

The work of the Committee has continued along the lines presented in the last annual report in following the paint tests undertaken by the Committee.

The results of the tests at Havre de Grace show that in nearly every case the paints on both the panels and the bridge proper are affording excellent protection after a little more than two and one-half years' exposure. The report of the last inspection made in March of this year is abstracted as follows:

MR. S. S. VOORHEES,
Chairman, Committee E, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

The last inspection of the Havre de Grace bridge made in March of this year showed no general depreciation in any marked way since last year's inspection of the various protective coatings under test, except their natural deterioration from time. The paint films showed the effect of time generally in the loss of any original luster or gloss, rather than in actual disintegration at this time, and it is expected that another year will permit some classification due to marked deterioration. Some differentiation in particular paints can already be made between the panels covered with the same coating at different rates of spreadings, but it is too early to draw any positive conclusions therefrom.

As stated above, another year should permit definite conclusions in many respects. Only the care with which the panels were treated will allow, when failure thereof is positive, accurate comparison therewith in the case of identical paints used on the large surface of the bridge proper.

(Signed) W. A. AIKEN,
Chairman, Sub-Committee on Inspection.

It is the intention of the Committee to have detailed photographic records made of the panels as soon as the condition of the paint films warrant such reproduction. It is also the intention to have the paint removed from one of the panels in each set by a paint remover and a photographic record and careful examination made of the surface of the metal. The condition of the steel

under the paint film will be noted with much interest in the light of recent laboratory experiments showing the different actions of certain pigments on corrosion. The information gained from this practical service test will be of great importance in determining the value of the laboratory test.

The last inspection of the wooden panels at Atlantic City furnishes some interesting information. It should be stated, however, that Committee E has only acted in an inspecting capacity for this set of tests. The report of the Sub-Committee on Inspection is as follows:

MR. S. S. VOORHEES,
Chairman, Committee E, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

An inspection was made March 27, 1909, at Atlantic City by the Sub-Committee on Inspection of Wooden Panels Test Fence. The following members of the Sub-Committee were present: Messrs. Aiken Job, Sabin, Voorhees; Dr. Dudley and other members of Committee E were also present.

It was found that the lithopone panels had completely failed, and authority was given the Paint Manufacturers' Association to remove panels, formulas 21 to 28 inclusive, and substitute other formulas which the Association may wish to test. The composition of the lithopone formulas ranged from 100 per cent. lithopone to 60 per cent. lithopone with various other pigments. In most cases the coating had so completely perished that the bare board was visible in spots, and on the rest of the surface the life of the coating had completely gone. The time of exposure was about one year, and the corresponding panels on both sides of the fence had failed about equally.

The Sub-Committee found that all of the pure white lead panels chalked considerably and were in less efficient condition in this respect than many of the composition paints. The relative efficiency of the latter will be reported from time to time.

It was found in general that the tints were in considerably better condition than the corresponding whites, and that the results upon cypress and yellow pine were often unsatisfactory owing to the character of the wood, and in order to facilitate close comparison at future inspections, the Paint Manufacturers' Association was authorized to remove the tints upon cypress and yellow pine and to group the whites together in such location that close examination can be made.

At the annual meeting of the Society it is hoped that inspection will be made by Committee E.

(Signed) ROBERT JOB,
Chairman, Sub-Committee.

This series of exposures has confirmed the statement made in last year's report, that the results will be of much value in simplifying a further set of tests to be undertaken entirely under the direction of Committee E.

A further investigation of the Committee has been undertaken to standardize the tests employed in the examination of linseed oil, so that when the tests and methods required to determine the quality of linseed oil are satisfactorily established, specifications for this material may be prepared.

To this end a sub-committee of eight was appointed as follows:

Gustave W. Thompson, Chairman, Chemist, National Lead Company, Brooklyn, N. Y.

S. S. Voorhees, Engineer of Tests, U. S. Geological Survey, Washington, D. C.

C. N. Forrest, New York Testing Laboratory, Maurer, N. J. Parker C. McIlhiney, Consulting Chemist, New York City, N. Y.

J. F. Walker, Chemist, Clements and Son Company, Philadelphia, Pa.

P. H. Walker, U. S. Bureau of Chemistry, Washington, D. C.

A. H. Sabin, Chemist, Flushing, N. Y.

Augustus H. Gill, Massachusetts Institute of Technology, Boston, Mass.

The chairman of this Sub-Committee has outlined and carried through this work with great care, and the results obtained from the different laboratories have added materially to our knowledge of the constants of commercially pure raw linseed oil. The data are of such value that the report of the Sub-Committee will be presented at this meeting, with a view of publication in full in the Proceedings.

REPORT OF SUB-COMMITTEE ON LINSEED OIL.

This Sub-Committee was appointed at a meeting of Committee E at the Annual Convention of the Society in 1908. It was considered desirable that the study of linseed oil should be undertaken systematically with the idea that such study would assist in the preparation of proper specifications for the purity and for the quality of linseed oil, and ultimately lead to better and more exact knowledge of how linseed oil should be used in order to

obtain the best results. This Committee, after considering carefully what was practicable, decided on the following plan for the year now ending: Samples of linseed of known purity were to be obtained and specifications for analysis prepared. Then, portions of these samples were to be distributed among competent chemists and the results of their examinations reported. Other portions of the samples were to be reserved for future work, particularly on points on which the testing chemists had disagreed. How far the work planned was carried out may be judged from the present report.

Four producers of linseed oil consented to allow samples of oil to be taken at their mills and contributed the oil needed for this work. These producers were the National Lead Co., the American Linseed Co., Hirst and Begley, and the Archer-Daniels Co.

Three "committees on sampling" were appointed to superintend the sampling of this oil. Their personnel is as follows:

New York City.—Parker C. McIlhiney, Chairman; A. H. Sabin, C. N. Forrest, R. E. Doolittle.

Chicago.—Edward Gudeman, Chairman; R. Smith, A. L. Winton.

St. Paul.—A. S. Mitchell, Chairman; Rodney M. West, F. G. Smith.

The specifications adopted for testing the samples are as follows:

SPECIFICATIONS FOR TAKING SAMPLES.

(a) *Sample to Represent.*—The sample shall represent the product of a given factory at a given time, as it comes from the presses (or what would correspond thereto), and be immediately filtered through paper.

(b) *Supervision.*—These samples shall be taken under the supervision of committees of three or more persons, which committees, respectively, shall certify that they have superintended the taking of their samples, describing the place, etc., at which they were taken, and the samples so taken shall be forwarded by express to the chairman of the Sub-Committee, 129 York Street, Brooklyn.

(c) *Quantity of Sample.*—About twenty gallons of the oil shall be placed in a clean receptacle and, after thorough agitation, shall be filled, when filtered, into forty clean quart bottles and two 5-gallon cans, which shall be properly stoppered, sealed and labeled. In addition to sealing, the cans should be soldered hermetically. The oil from the presses, or

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their equivalent, can be filtered and put in clean barrels, sealed and shipped to the laboratory of the Chairman of the Supervising Committee for bottling, after thorough mixing, if so desired. The bottles and cans will be furnished by the Sub-Committee. The bottles should be stoppered with clean sunk stoppers and sealed with a hot mixture of gelatine 11 oz., water 6 fluid oz., and glycerine 1 fluid oz., and when cold should be sealed with strip labels to be furnished by the Sub-Committee. The labels for the bottles will also be furnished by the Sub-Committee.

(d) *The Seed Used*.—A quart of the seed used shall be placed in a clean quart Mason jar, sealed and labeled and forwarded with the oil samples to the chairman of the Sub-Committee.

(e) *Filtering*.—The oil shall be filtered through a small filter-press using paper-filtering medium immediately after being taken from the presses or their equivalent, and before the oil becomes cold.

These sampling specifications could not be followed out entirely, as the reports of the sampling committees will indicate. There is every reason to believe, however, that the samples are valid, and all that they are represented to be. We give here the reports of the sampling committees:

NEW YORK, May 21, 1909.

MR. GUSTAVE W. THOMPSON, *Chairman*,
Brooklyn, N. Y.

Dear Sir:

On February 2 a committee consisting of Prof. A. H. Sabin, Mr. R. E. Doolittle, Mr. C. N. Forrest, and myself visited the Atlantic Mill of the National Lead Company in Brooklyn and there witnessed the preparation of forty 1-quart samples of linseed oil and also two 5-gallon-can samples, together with two 1-quart samples of the seed from which the oil was manufactured. The samples of seed were taken by the automatic sampler in regular use in the mill, which sampled the seed going to one of the sets of rolls which were used to grind the seed. From the grinding rolls the seed went to a heating tub in which it was heated by steam, and from this heater it was pressed in hydraulic presses. From the hydraulic presses the oil was taken to a small hand-filter press in which it was filtered through paper. This hand-filter press did not work perfectly and in consequence the oil obtained was not perfectly filtered, but was slightly turbid, and the samples were bottled with this slight turbidity evenly distributed through it.

Every facility was afforded to your Committee for making a complete identification of the oil and seed, and the Committee kept the process under continuous inspection, so that there can be no doubt that the oil of which the samples were prepared at that time was actually obtained from the seed of which a sample was also taken.

Respectfully,

(Signed)

PARKER C. McILHINEY.

CHICAGO, February 10, 1909.

MR. G. W. THOMPSON, *Chairman*,
Brooklyn, N. Y.

Dear Sir:

As per your request, Prof. R. Smith, Dr. A. L. Winton, and myself obtained for you authentic samples of the linseed oil made at the Hirst and Begley Mill, Chicago, Ill., and the American Linseed Company Mill, South Chicago.

Hirst and Begley Mill.—The samples, taken February 3, 1909, consist of 20 gallons of linseed oil and 1 quart of linseed, representing seed from which oil was pressed. It was not possible for the Committee to filter-press the oil at the mill. The sample represents the filtered oil, as filtered through the mill press. As the Committee were present during pressing, and watched the filtering, and run of oil into the tank, there is no doubt in their minds that this sample is pure raw linseed oil. The process in use at the Hirst and Begley Mill is that of direct pressure with Anderson expellers. The oil runs from the presses comparatively cold, the ground seed not being cooked or steamed as in the hydraulic process. The foots separated in the filter press are continually returned to be treated as fresh seed. The oil is bright, clear, nearly odorless and tasteless.

American Linseed Company Mill.—The samples, taken February 6, 1909, consist of 20 gallons of linseed oil and 1 quart of linseed, representing average of seed from which oil was pressed. It was impossible for the Committee to filter-press the oil at the mill. The sample represents the filtered oil, as filtered through the mill presses. The Committee feels assured that the samples of oil taken are pure and represent the crude linseed oil made by this process. The process used at the South Chicago mill of the American Linseed Company is that of direct extraction with naphtha. It is not possible to follow this process directly, as the time from linseed to linseed oil is from four to five days. The system involves extraction in batteries of percolators. The oil from the extraction tank is then run into the evaporators and the naphtha is separated. The oil from the pans is purified by having the small amount of foots separated in a centrifugal machine, which also takes out some of the water due to the use of steam in the separation of the naphtha. The oil is then heated and filtered through cloth. The sample of oil taken is the filtered oil as it comes from the mill filters. At this mill special grades of linseed oil are made, and the raw oil taken is not a commercial product. Their examination of the plant leads the Sampling Committee to the conclusion that the sample of oil taken is pure linseed oil. The sample of oil was taken from the pump to the refinery. A superficial examination of this mill justifies the Sampling Committee in concluding that nothing but straight linseed oil is made at this plant, and that the samples taken represent a fair average of raw linseed oil as made by the naphtha extraction process.

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At both mills, that of Hirst and Begley, and that of the American Linseed Company, every facility was offered your Sampling Committee to assure themselves that nothing but straight linseed is used and that the oils are straight, pure linseed oils.

(Signed) EDWARD GUDEMAN, *Chairman*.

ST. PAUL, MINN., February 19, 1909.

MR. GUSTAVE W. THOMPSON, *Chairman*,
Brooklyn, N. Y.

Dear Sir:

On Saturday last Mr. Rodney M. West, Assistant State Analyst of Minnesota, Mr. F. G. Smith, Assistant Chemist, Food and Drug Inspection Laboratory, Bureau of Chemistry, U. S. Department of Agriculture, and myself visited the works of the Archer-Daniels Linseed Co. at Minneapolis, and secured the forty 1-quart samples of linseed oil requested, and also two 5-gallon cans, together with one quart of the seed from which the oil was manufactured. The sample of seed was secured by gathering from 1 to 2 ounces every five minutes from each of the four roller mills which were feeding one "cooker," for a period of an hour and a quarter. These small samples were mixed into a composite sample, from which the quart was taken.

After allowing for the time necessary for the seed, which we saw milled, to pass through the "cooker," this hot meal was pressed in the usual manner, using a maximum pressure of slightly above 3,000 lbs. per sq. in. The oil from the presses was received in an empty scale-tank in the basement, and pumped to a clean tank upon the third floor, whence it filtered by gravity through one of the large presses from which all slimes had been removed. The middle run from this filtration was secured by intercepting the stream from the filter, and was placed in 10-gallon cans. It was bottled at the laboratory three days later.

This oil has not been filtered while hot through paper, as directed, but has received, as stated, but one filtration through canvas. It is customary at the works to filter all oil twice through canvas, and the second filtration is done upon filters which contain some sludge. A filter does not reach its maximum efficiency until it has been in use for a short period. It was impossible to give this oil two filtrations, as two large presses could not be cleaned and made available. It is customary to perform the final clarification by sedimentation in the storage.

As the samples required amount to 20 gallons, an amount largely in excess of that anticipated by the Archer-Daniels firm, it is not improbable that a bill will be rendered for this oil.

Kindly advise me as to the disposition of the samples taken. I would suggest that they be not shipped in one lot in the box as sent, for the reason that three of the empty bottles were broken in transit and the weight would be excessive when filled.

Respectfully,

(Signed) A. S. MITCHELL, Chief, St. Paul Laboratory.

In order to enlist general support in our work, about 150 letters were sent to chemists throughout the country, and the following circular letter was distributed:

AMERICAN SOCIETY FOR TESTING MATERIALS.

February 9, 1909.

Dear Sir:

This Society's Committee E (on Preservative Coatings) has taken up the subject of the so-called Constants of Linseed Oil. Four samples of known purity are being prepared, taken from different mills of the country, and they will be ready for distribution in the latter part of February for analysis. This entire matter has been placed in the hands of the undersigned as a Sub-Committee. The tests decided on as essential are:

1. Specific Gravity.
2. Turbidity and Foots.
3. Breaking Test.
4. Moisture and Volatile Matter.
5. Ash.
6. Drying Test on Glass.
7. Oxygen Absorption.
8. Acid Number.
9. Saponification Number.
10. Unsaponifiable Matter.
11. Liebermann-Storch Test.
12. Refractive Index.
13. Acetyl Value.
14. Hexabromide Test.
15. Iodine Number.

Specifications for analytical work are now being prepared. It is very desirable that this work should be done in the most thorough and scientific manner possible, and that no one undertake it except with that understanding. The results should be forwarded to the Chairman of the Sub-Committee by May 20, 1909.

Will you volunteer to test these samples? The results will be published in the report of the American Society for Testing Materials, and you will be given full credit for your part therein.

The result was that the following chemists consented to examine the samples and report on them.

1. G. W. Thompson, 129 York Street, Brooklyn, N. Y.
2. Parker C. McIlhiney, 7 East 42nd Street, New York City.
3. Percy H. Walker, Contracts Laboratory, U. S. Department of Agriculture, Bureau of Chemistry, Washington, D. C.

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4. A. H. Gill, Massachusetts Institute of Technology, Chemical Dept., Boston, Mass.
5. S. S. Voorhees, Engineer of Tests, Department of the Interior, U. S. Geological Survey, Washington, D. C.
6. Glenn H. Pickard, care of Spencer Kellogg & Co., Buffalo, N. Y.
7. Stillwell & Gladding, 181 Front Street, New York City.
8. Albert F. Seeker, Food & Drug Laboratory, U. S. Appraiser's Stores, New York City.
9. H. M. Loomis, Acting Chief of Food and Drug Inspection Laboratory, Arcade Annex, Seattle, Washington.
10. H. H. Knisely, 310 Worcester Building, Portland, Oregon.
11. A. J. Patten, Lansing, Michigan.
12. S. R. Mitchell, Agricultural College, New Mexico.
13. J. E. Greaves, Logan, Utah.
14. E. F. Ladd, Fargo, North Dakota.
15. L. M. Tolman, U. S. Department of Agriculture, Washington, D. C.
16. J. C. Dickerman, Madison, Wisconsin.
17. F. S. Kedsie, Lansing, Michigan.
18. H. H. Hanson, Orono, Maine.
19. J. S. Jones, Moscow, Idaho.
20. J. B. Lindsay, Amherst, Mass.
21. Paul Schweitzer, University of Missouri, Columbia, Mo.
22. Edward J. Shanley, Manhattan Building, Chicago, Ill.
23. C. B. Dudley, Pennsylvania Railroad, Altoona, Pa.
24. A. S. Mitchell, Old State House, St. Paul, Minn.
25. C. E. Waters, Bureau of Standards, Washington, D. C.
26. Arthur D. Little, 93 Broad Street, Boston, Mass.
27. Otto Eisenschimml, American Linseed Company, South Chicago, Ill.
28. Archer-Daniels Linseed Company, Minneapolis, Minn.
29. L. F. Williams, The North Carolina College of Agriculture and Mechanic Arts, West Raleigh, N. C.
30. M. H. Wickhorst, Engineer of Tests, Chicago, Burlington & Quincy Railroad, 209 Adams Street, Chicago, Ill.
31. A. P. Bjerregaard, Agricultural College, New Mexico.

Labels of the following form were used on these samples:



AMERICAN SOCIETY FOR TESTING MATERIALS

SAMPLE OF

Taken at **NR11**

Remarks.....

1909

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

Chapters

These samples, which were distributed about March 1, 1909, were labeled as follows:

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of Linseed Oil

Taken at	National Lead Co.'s Atlantic Branch	Mill.
Remarks	Old Process. Hot Pressed.	

Feb. 2, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

PARKER C. McILHINEY, *Chairman.*
A. H. SABIN,
R. E. DOOLITTLE.

ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. 149

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of
Linseed Oil—Raw
Taken at Hirst & Begley, Chicago, Mill.
Remarks Anderson—Expellers.

Feb. 3, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

EDWARD GUDEMAN, *Chairman*.
W. R. SMITH,
A. L. WINTON.

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of
Linseed Oil—Raw
Taken at American Linseed Co., South Chicago, Mill.
Remarks Naphtha Process
Oil Filtered through Mill Press.

Feb. 6, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

EDWARD GUDEMAN, *Chairman*.
W. R. SMITH,
A. L. WINTON.

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of
Raw Linseed Oil
Taken at Archer-Daniels Linseed Co., Minneapolis, Mill.
Remarks Cleaned once through cloth in cleaned large filter-press
at mill.

Feb. 13, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

A. S. MITCHELL, *Chairman*.
RODNEY M. WEST,
F. G. SMITH.

With each set of samples there was also sent a sample of C. P. bichromate of potassium, to be used in the standardization of the Hanus solution, and a sample of litharge to be used in the oxygen absorption test. The following letter was also sent to each analyst.

March 1, 1909.

CIRCULAR EXPLAINING THE PURPOSES AND PLANS IN
RELATION TO THE OBTAINING OF SAMPLES OF
LINSEED OIL OF KNOWN PURITY AND THEIR
EXAMINATION.

EXPLANATORY.

At the meeting of Committee E on Preservative Coatings at Atlantic City in June, 1908, the suggestion was made that a sub-committee be appointed for the purpose of having samples of linseed oil taken from different sources and having them tested by competent chemists, thereby determining the so-called Constants of Linseed Oil. Arrangements, accordingly, were made to have these samples taken at the Old Process Mills of the National Lead Company in New York and the Archer-Daniels Company in Minneapolis, also at the Hirst and Begley Mill (Anderson Process) in Chicago, and the American Linseed Oil Co.'s Mill (Extraction Process) in Chicago. Committees were appointed to take these samples in the several localities, according to specifications issued by this sub-committee. These samples have been taken and are being distributed for analysis. The tests to be applied are given in detail below. It is hoped that the reports on the examination of these samples will be ready for the annual meeting of the American Society for Testing Materials in June, next.

TESTS TO BE APPLIED.

After careful consideration, the following tests have been selected as those which the Sub-Committee asks to have applied. If there are other tests which the chemist cares to apply, he is at liberty to do so after these specified tests have been followed; in which case, he is requested to report to the Committee the results of his extra tests and the methods he has followed:

General.—All tests are to be made on oil which has been filtered at a temperature of between 60° and 80° F. through paper in the laboratory immediately before weighing out, except tests No. 2—Turbidity and Fouts, No. 4—Moisture and Volatile Matter and No. 5—Ash. The sample should be thoroughly agitated before the removal of a portion for filtration or analysis.

1. *Specific Gravity.*—Use a pyknometer, accurately standardized and having a capacity of at least 25 c.c., making a test at 25° C., water being 1 at 25° C., and another test at 15.5° C., water being 1 at 15.5° C.

2. *Turbidity and Fouts*.—By allowing 25 c.c. of the oil to stand between 60° and 80° F. for two weeks in a graduated glass tube, one centimeter in diameter, reporting amount of sediment found in c.c.'s or in fractions thereof.

3. *Breaking Test*.—By heating a portion of the oil, say 15 c.c., in a $\frac{1}{2}$ x 6-in. test tube over an open flame to 300° C., the temperature to be determined by a thermometer suspended in the oil. The rise in temperature should not exceed 50° per minute. Report whether oil breaks or not.

4. *Moisture and Volatile Matter*.—(a) Loss sustained by 2 grams of the oil in a 4-oz. Erlenmeyer flask at 105° C. in a current of dry hydrogen or pure carbonic acid gas (free from sulphur) to constant weight. (b) Loss sustained by 5 grams of oil in a 2½-in. uncovered Petri dish at 100° C. in an ordinary steam-jacketed oven for two hours.

5. *Ash*.—By burning 10 grams to complete combustion and to a light gray residue in a porcelain crucible or dish at a dull red heat.

6. *Drying Test on Glass*.—Follow Archbutt's method ("A piece of polished plate glass seven centimeters square by four millimeters thick is cleaned and counterpoised on the balance; it is then heated for an hour at 200° C. in an air bath to dry it thoroughly. It is taken out and laid on a non-conductor, allowed to cool for three or four minutes and the hot glass thinly painted with the oil to be tested, using a camel hair brush. When the glass is cold it is weighed and sufficient oil added to make it up to 0.1 gram." Gill's description) in the preparation of the glass slips and their coating with oil, placing in an atmosphere moderately dry, say a closet dessicator dried with sulphuric acid in which the moisture is not more than 25 per cent. saturation (temperature 60° to 80° F.). Report time required for the oil to become dry to the touch—i. e., no oil sticks to or is removed by the finger when touched lightly.

7.* *Oxygen Absorption, Using Lead Monoxide*.—Follow the method described in Department of Agriculture, Bureau of Chemistry, Bulletin 109, page 7. The sample of lead monoxide for use in this test will be furnished by the Committee. Report maximum gain and time to reach it.

8. *Acid Number*.—Expressed in milligrams of KOH per gram of oil. Follow the method described in Department of Agriculture, Bureau of Chemistry, Bulletin 107, revised page 142.

9. *Saponification Number*.—Expressed as with acid number and stating length of time test is run. Blanks should also be run to cover effect of alkali in glass. Follow the method given in the above referred to Bulletin 107, pages 137-138.

10. *Unsaponifiable Matter*.—Follow Boemer's method taken from Ubbelohde's *Handbuch der Ole u. Fette*, p. 261-2. "To 100 grams of oil in a 1000 to 1500-c.c. Erlenmeyer flask add 60 c.c. of an aqueous solution of potassium hydroxide (200 grams KOH dissolved in water and made

* Request was made later on that tests be made using ten (10) grams of litharge as well as five (5).

up to 300 c.c.) and 140 c.c. of 95 per cent. alcohol. Connect with a reflux condenser and heat on the water bath, shaking at first until the liquid becomes clear. Then heat for one hour with occasional shaking. Transfer while yet warm to a 2000-c.c. separatory funnel to which some water has been added, wash out the Erlenmeyer with water using in all 600 c.c. Cool, add 800 c.c. of ether and shake vigorously one minute. In a few minutes the ether solution separates perfectly clear. Draw off the soap and filter the ether (to remove last traces of soap) into a large Erlenmeyer and distill off the ether, adding if necessary one or two pieces of pumice stone. Shake the soap solution three times with 400 c.c. of ether, which add to the first ether extract. To the residue left after distilling the ether add 3 c.c. of the above KOH solution, and 7 c.c. of the 95 per cent. alcohol, and heat under reflux condenser for ten minutes on the water bath. Transfer to a small separatory funnel, using 20 to 30 c.c. of water, and after cooling shake out with two portions of 100 c.c. of ether; wash the ether three times with 10 c.c. of water. After drawing off the last of the water, filter the ethereal solution so as to remove the last drops of water, distill off the ether, dry residue in water oven and weigh."

After determination of unsaponifiable matter, convert it to acetate and determine the melting point of the acetate as directed by Lewkowitsch, page 372, Third Edition.

11. *Liebermann-Storch Test*.—Qualitative. Follow the method described in Bulletin 109 of Department of Agriculture, Bureau of Chemistry, referred to above.

12. *Refractive Index*.—Using Abbé Refractometer at 25° C.

13. *Acetyl Value*.—Follow Benedikt-Lewkowitsch method. See Department of Agriculture, Bureau of Chemistry, Bulletin 107, revised page 142.

14. *Hexabromide Test*.—On oil, determining the melting point of the bromide compounds. Method to be followed: The determination should be made in glass-stoppered weighing bottles, about 6 ins. high and 1 in. in diameter, with flat bottom, and weighing about 30 grams each. These bottles should be carefully dried and weighed. Weigh into one of these bottles 0.3 gram of oil to be tested; add 25 c.c. of absolute ether; cool to near 0° Centigrade; add bromine, drop by drop, until a considerable excess is shown by the color of the solution. Stir constantly during this addition, and add bromine very slowly to avoid heating. Place tube in ice water for thirty minutes; then in centrifuge, whirling for two minutes at speed of 1,200 revolutions per minute. This throws the brominated oil to the bottom of the tube, from which the supernatant liquid can be easily and quickly decanted. Add 10 c.c. of cold ether; stir precipitate with glass rod; allow to stand in ice water until thoroughly cold. Whirl in centrifuge again, and decant supernatant liquor. Another washing in the same manner will remove the excess of bromine and oil. Allow the tube and residue to stand for a short time, until the ether has evaporated; dry in water bath for thirty minutes, and weigh (Tolman's method).

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Where it is impracticable to follow the above described method, follow such other method as may appeal to the analyst, describing it in the report.

15. *Iodine Number*.—Follow the Hanus method as described in Department of Agriculture, Bureau of Chemistry, Bulletin 107, revised page 136.

IMPORTANCE OF THIS WORK.

The importance of this work is clearly seen when it is considered that most of our State legislatures have passed bills prohibiting the adulteration of linseed oil. Linseed oil is largely purchased on specifications, which specifications would be very much improved if the Constants of Linseed Oil were used, provided these Constants were accurately determined. The purpose of this examination is to furnish data on which to base such specifications and provide such standards of purity.

Report these samples by numbers: No. 1, National Lead Company's; No. 2, Hirst & Begley's; No. 3, American Linseed Company's; No. 4, Archer-Daniels Company's.

Each sampling committee also took, as was directed, a sample of the seed used in the production of the linseed oil sampled. These samples were labeled as follows:

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of
Flaxseed

Taken at	National Lead Co.'s Atlantic	Mill.
Remarks	Taken by automatic sampler as seed went through grinding rolls.	

Feb. 2, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

PARKER C. McILHINEY, *Chairman*.
C. N. FORREST.

AMERICAN SOCIETY FOR TESTING MATERIALS

Sample of
Linseed

Taken at	Hirst & Begley	Mill.
Remarks	Same as average seed from which oil was extracted.	

Feb. 3, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

EDWARD GUDEMAN, *Chairman*.
W. R. SMITH,
A. L. WINTON.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Sample of
Linseed
Taken at American Linseed Co., S. Chicago, Ill., Mill.
Remarks Same as average from which oil was extracted.

Feb. 6, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

EDWARD GUDEMAN, *Chairman.*
A. L. WINTON,
W. R. SMITH.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Sample of
Flaxseed
Taken at Archer-Daniels Linseed Co., Minneapolis, Mill.
Remarks A mixed composite sample corresponding to the oil sampled on same day.

Feb. 13, 1909.

The undersigned committee certify that the sample described above and contained within has been taken under their supervision and according to directions of the above Society's sub-committee.

A. S. MITCHELL, *Chairman.*
RODNEY M. WEST,
F. G. SMITH.

The samples of seed were sent to F. W. Eva, Chief Inspector of Grain for the State of Minnesota in St. Paul, Minnesota, for examination. His report is as follows:

MR. GUSTAVE W. THOMPSON, *Chairman,*
Brooklyn, N. Y.

Dear Sir:

This will acknowledge receipt of your favor of the 20 inst., with check for \$3.00 in payment of inspection on four samples of flaxseed, which also reached me this morning.

I have personally tested these samples and enclose herewith certificates covering same, viz: Samples Nos. 1, 2, and 3, Grade No. 1 flaxseed, with $1\frac{3}{4}$, $1\frac{1}{2}$ and $1\frac{1}{4}$ per cent. dockage, respectively, and sample No. 4,

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Grade No. 1, Northwestern, with 4 per cent. dockage. The dockage on the last sample is largely composed of mustard seed and cracked flaxseed. In fact all of the samples show quite a percentage of cracked flaxseed.

I am returning the samples by express to-day.

Yours truly,

(Signed)

F. W. Eva,
Chief Inspector.

STATE OF MINNESOTA					
OFFICE OF					
Chief Inspector of Grain					
ST. PAUL DISTRICT					
St. Paul, Minn., <u>May 24 - 1909</u>					
THIS CERTIFIES, That there was inspected, under the supervision of the State Grain Inspection Department:					
(MINNESOTA GRADES)					
CAR NUMBER	CAR INITIAL	DATE INSPECTED	CONTENTS	GRADE	REMARKS
<u>Sample No 1</u>		<u>24/09</u>	<u>Flax</u>	<u>No 1 - 1 3/4 %</u>	
F. W. EVA, CHIEF INSPECTOR ST. PAUL, MINN.				<u>F. W. Eva</u> CHIEF INSPECTOR	

STATE OF MINNESOTA					
OFFICE OF					
Chief Inspector of Grain					
ST. PAUL DISTRICT					
St. Paul, Minn., <u>May 24 - 1909</u>					
THIS CERTIFIES, That there was inspected, under the supervision of the State Grain Inspection Department:					
(MINNESOTA GRADES)					
CAR NUMBER	CAR INITIAL	DATE INSPECTED	CONTENTS	GRADE	REMARKS
<u>Sample No 2</u>		<u>24/09</u>	<u>Flax</u>	<u>No. 1 - 1 1/2 %</u>	
F. W. EVA, CHIEF INSPECTOR ST. PAUL, MINN.				<u>F. W. Eva</u> CHIEF INSPECTOR	

STATE OF MINNESOTA

OFFICE OF

Chief Inspector of Grain

ST. PAUL DISTRICT

St. Paul, Minn., May 24 1909

THIS CERTIFIES, That there was inspected, under the supervision
of the State Grain Inspection Department:

(MINNESOTA GRADES)

CAR NUMBER	CAR INITIAL	DATE INSPECTED	CONTENTS	GRADE	REMARKS
Sample No 3		7/24/09	Flax	No 1- 1 1/2 %	

F. W. EVA,
CHIEF INSPECTOR
ST. PAUL, MINN.

F. W. Eva

STATE OF MINNESOTA

OFFICE OF

Chief Inspector of Grain

ST. PAUL DISTRICT

St. Paul, Minn., May 24 1909

THIS CERTIFIES, That there was inspected, under the supervision
of the State Grain Inspection Department:

(MINNESOTA GRADES)

CAR NUMBER	CAR INITIAL	DATE INSPECTED	CONTENTS	GRADE	REMARKS
Sample No 4		7/24/09	Flax	No 1. 725-4%	

F. W. EVA,
CHIEF INSPECTOR
ST. PAUL, MINN.

F. W. Eva

The reports of the results, so far received, are given on the following pages in tabulated form, with the analyst's number in the first column. The individual reports in full appear in Appendix I.

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TABULATED RESULTS OBTAINED BY TESTING LINSEED OIL SAMPLES.

1a. *Specific Gravity at 15.5° C.*

Analyst. Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1....0.9346	0.9338	0.9338	0.9346
3....0.9342	0.9327	0.9326	0.9341
6....0.9344	0.9313	0.9319	0.9330
7....0.9349	0.9333	0.9336	0.9351
8....0.9344	0.9330	0.9331	0.9344
9....0.9342	0.9331	0.9329	0.9341
12....0.9343	0.9325	0.9336	0.9343
15....0.9341	0.9328	0.9330	0.9339
17....0.9356	0.9349	0.9346	0.9352
22....0.9342	0.9329	0.9330	0.9339
24....0.9352	0.9334	0.9334	0.9344
25....0.9338	0.9328	0.9324	0.9342
26....0.9352	0.9335	0.9336	0.9352
29....0.9355	0.9340	0.9344	0.9361
31....0.9348	0.9325	0.9330	0.9340

1b. *Specific Gravity at 25° C.*

1....0.9298	0.9285	0.9286	0.9294
3....0.9298	0.9283	0.9283	0.9296
6....0.9284	0.9268	0.9271	0.9280
7....0.9291	0.9283	0.9283	0.9294
8....0.9298	0.9286	0.9286	0.9299
9....0.9297	0.9280	0.9283	0.9297
12....0.9303	0.9287	0.9284	0.9291
15....0.9300	0.9278	0.9287	0.9295
17....0.9287	0.9264	0.9267	0.9291
22....0.9289	0.9274	0.9277	0.9289
24....0.9301	0.9284	0.9288	0.9298
25....0.9298	0.9286	0.9287	0.9302
26....0.9300	0.9286	0.9287	0.9300
29....0.9303	0.9290	0.9296	0.9310
31....0.9296	0.9281	0.9285	0.9294

2. *Turbidity and Fouts in Cubic Centimeters.*

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.....	0.75	0.10	0.65	0.65
3.....	0.80	0.50	0.50	0.50
6.....	0.70	0.50	0.50	0.62
7.....	0.85	0.40	0.40	0.60
8.....	1.00	0.50	0.50	0.90
9.....	0.70	0.25	0.25	0.70
12.....	0.60	0.65	0.75	0.50
15.....	0.90	0.40	0.30	0.80
17.....	0.60	0.20	0.25	0.55
22.....	0.90	0.30	0.40	0.80
25.....	0.71	0.14	0.21	0.64
26.....	0.80	0.25	0.30	0.55
30.....	0.80	0.40	0.30	0.70
31.....	0.50	0.20	0.30	0.50

3. *Breaking Test.*

1.....	yes	no	no	yes
3.....	"	"	"	"
6.....	"	"	"	"
7.....	"	"	"	no
8.....	"	"	yes	yes
9.....	"	"	no	"
12.....	no	"	"	"
15.....	yes	"	"	"
17.....	no	"	"	"
22.....	yes	"	"	"
25.....	"	"	"	"
26.....	"	"	"	"
29.....	"	"	"	"
30.....	"	"	"	"
31.....	"	"	"	"

4a. *Percentage of Moisture and Volatile Matter in Current of (Column 6).*

1.....	0.022	0.071	0.200	0.046	H ₂
3.....	0.100	0.120	0.330	0.090	CO ₂
7.....	0.119	0.200	0.235	0.120	
15.....	0.000	0.000	0.120	0.000	
17.....	0.756	0.534	0.0488	0.491	
22.....	0.04	0.02	0.06	none	H ₂
25.....	0.030 gain	0.50	0.130	0.020	CO ₂
31.....	0.10 "	0.13 gain	0.08	0.08 gain	H ₂

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4b. Percentage of Moisture and Volatile Matter in Oven at 100° C.

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.....	0.073	0.060	0.219	0.065
3.....	0.090	0.090	0.260	0.08
7.....	0.009	slight gain	0.148	slight gain
8.....	0.080	0.090	0.230	0.060
9.....	0.052	0.041	0.212	0.056
12.....	none	0.040 gain	0.170	none
17.....	0.097	0.037	0.166	0.118
22.....	0.004	none	0.160	0.03
25.....	0.016	0.013 gain	0.128	0.052
26.....	0.054	0.231	0.217	0.034
29.....	0.032	0.023	0.209	0.045
30.....	0.030 gain	0.100 gain	0.090	0.030
31.....	0.055 "	0.000	0.185	0.010 gain

5. Percentage of Ash.

1.....	0.116	0.017	0.039	0.096
3.....	0.200	trace	0.030	0.190
6.....	0.135	0.033	0.060	0.170
7.....	0.135	0.025	0.030	0.160
8.....	0.140	0.030	0.040	0.160
9.....	0.140	0.025	0.034	0.149
12.....	0.135	0.035	0.050	0.145
15.....	0.120	0.010	0.030	0.160
17.....	0.125	0.030	0.030	0.131 on filtered
22.....	0.140	0.025	0.040	0.160 [solution.
25.....	0.139	0.028	0.038	0.154
26.....	0.135	0.030	0.040	0.143
29.....	0.134	0.027	0.033	0.163
30.....	0.140	0.030	0.042	0.162
31.....	0.156	0.047	0.048	0.159

6. Drying Test on Glass in Hours.

1.....	134	120	120	134
3.....	180-192	108-144	96-108	180
7.....	84	72	84	72
8.....	264	288-312	288	240
9.....	80	67-71	87-115	84-93
22.....	72	75	72	72
25.....	30	30	30	30 drying not
26.....	140	120	100	160 [complete.
30.....	108	116	158	170
31.....	168	120	144	168

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7a. Oxygen Absorption—5 Grams PbO.

Analyst.	Sample No. 1.		Sample No. 2.		Sample No. 3.		Sample No. 4.	
	Per cent.	Time, hours.	Per cent.	Time, hours.	Per cent.	Time, hours.	Per cent.	Time, hours.
3...	15.5	120	11.8	120	9.6	120	11.0	120
4...	1.5	168	9.5	168	10.8	168	9.1	168
6...	16.6	144	12.7	144	13.5	144	13.6	144
7...	15.10	93	13.9	72	12.50	48	14.2	88
8...	7.47	96	7.87	96	8.18	96	9.37	96
9...	11.03	118	8.92	93	8.70	95	9.40	115
17...	6.48	48	6.48	48	6.41	48	7.60	48
22...	13.10	...	10.69	...	10.59	...	10.76	...
25...	6.23	48	8.11	48	9.01	48	8.39	48
26...	10.75	120	4.97	120	11.24	120	9.76	120
30...	10.19	100	10.41	100	10.53	100	10.57	100
31...	6.28	540	5.11	540	6.74	540	6.86	540

7b. Oxygen Absorption—10 Grams PbO.

1...	19.54	120	18.97	120	17.79	120	18.05	120
3...	15.5	120	13.2	120	15.3	120	15.3	120
4...	19.00	168	13.30	168	15.10	168	14.40	168
6...	14.6	144	14.4	96	14.6	96	14.5	96
9...	14.73	118	13.58	93	14.0	95	14.95	93
15...	9.08	48	6.77	48	9.30	48	8.30	48
22...	15.16	...	14.09	...	13.96	...	14.44	...
25...	13.79	120	13.40	240	13.29	120	13.68	120
26...	14.03	65	13.04	65	13.20	65	14.08	65
31...	15.04	277	11.53	540	14.64	277	15.17	277

8. Acid Number.

1.....	0.99	2.83	1.67	1.46
3.....	1.00	3.40	1.80	1.50
4.....	0.90	3.30	1.10	1.40
6.....	1.20	3.65	2.20	1.75
7.....	1.30	3.10	1.90	1.70
8.....	1.12	3.42	1.76	1.34
9.....	1.18	3.57	1.98	1.71
12.....	1.26	3.36	1.89	1.54
15.....	1.14	3.50	1.93	1.57
17.....	1.12	3.77	2.17	1.69
20.....	1.00	3.32	1.67	1.31
22.....	1.20	3.73	2.07	1.66

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8. Acid Number (Continued).

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
24.....	1.37	3.64	2.09	1.62
25.....	1.15	3.75	2.06	1.70
26.....	1.20	3.57	1.95	1.71
31.....	1.21	3.49	1.91	1.57

9. Saponification Number.

1.....	190.1	191.2	190.7	191.0
3.....	190.2	190.6	190.2	190.1
6.....	188.6	189.6	189.2	189.7
7.....	190.7	191.4	189.7	190.0
8.....	190.1	189.1	189.2	190.5
9.....	192.2	191.4	190.8	190.4
12.....	190.8	191.2	191.2	190.0
15.....	189.9	188.6	189.4	189.2
17.....	189.98	190.6	189.6	188.7
20.....	191.58	190.4	190.69	190.86
22.....	191.31	191.23	191.1	190.9
24.....	191.7	191.4	191.1	191.0
25.....	190.7	190.3	189.7	190.5
26.....	193.4	193.1	192.7	194.4
31.....	184.5	183.7	183.7	185.5

10a. Percentage of Unsaponifiable Matter.

1.....	0.85	0.94	0.96	0.86
3.....	1.08	1.03	1.02	1.08
7.....	1.02	0.98	0.96	1.05
9.....	1.15	0.83	1.41	1.71
17.....	0.99	0.98	1.05	0.99
22.....	0.97	1.03	0.98	1.12
25.....	0.90	0.68	1.00	0.84 using petroleum ether
26.....	0.94	0.92	0.94	0.94

10b. Unsaponifiable Matter—Melting Point of Acetate in Degrees Centigrade.

3.....	126	126	128	127
9.....	125.5	120	126	121
17.....	128-130	128-130	128-130	128-103
26.....	129	105.5	104	103

11. *Liebermann-Storch Test—Colors.*

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1....	Green	Green	Slight green	Slight green
3....	Pale green	Pale green	Pale green	Pale green
6....	Negative	Negative	Negative	Negative
7....	"	"	"	"
8....	"	"	"	"
9....	Dark brown	Dark brown	Blackish brown	Blackish brown
12....	Negative	Negative	Negative	Negative
15....	"	"	"	"
17....	"	"	"	"
22....	"	"	"	"
25....	"	"	"	"
26....	"	"	"	"
30....	"	"	"	"

12. *Refractive Index at 25° C.*

1....	1.4799	1.4790	1.4793	1.4793
3....	1.4805	1.4793	1.4795	1.4798
4....	1.4805	1.4803	1.4802	1.4801
6....	1.4805	1.4800	1.4800	1.4800
7....	1.4794	1.4794	1.4798	1.4800
8....	1.4802	1.4798	1.4802	1.4801
9....	1.4800	1.4796	1.4799	1.4799
15....	1.4796	1.4792	1.4790	1.4783
17....	1.4798	1.4793	1.4796	1.4798
22....	1.4797	1.4795	1.4795	1.4795
24....	1.4800	1.4794	1.4795	1.4797
25....	1.4780	1.4772	1.4775	1.4775
26....	1.4799	1.4795	1.4800	1.4800

13. *Acetyl Value.*

1.....	26.4	24.4	27.1	21.6
3.....	4.1	4.2	4.1	5.7
7.....	11.7	9.9	7.8	7.9
9.....	29.95	29.08	29.13	29.11
17.....	27.05	12.9	21.7	19.8
24.....	14.8	14.8	12.0	12.7
25.....	5.42	6.20	6.30	4.78
	4.63	5.40	4.41	5.43
26.....	21.4	27.8	25.0	30.5

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14a. Hexabromide Test.

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.....	30.3 30.6 25.3	30.87 28.91	29.55	19.84
3.....	44.0	44.5	39.3	41.2
4.....	26.20 24.9	19.4 19.1	11.8 12.0	14.2 14.2
7.....	41.1	38.4	39.0	37.9
9.....	46.3 27.7 34.7 48.1 26.5 34.6	39.3 21.6 24.1 44.1 20.0 29.9	42.3 27.1 34.6 43.9 25.6 39.1	35.6 22.9 32.6 46.0 26.5 35.0
15.....	42.9	42.9	44.8	39.0
17.....	56.6	49.3	48.1	48.2
22.....	40.9	39.7	40.5	40.0
25.....	41.1 41.0	36.7 41.1	38.6 39.3	43.0 43.4
		48.8		

14b. Hexabromide Test—Melting Point of Hexabromide in Degrees Centigrade.

3.....	150	151	149	150
7.....	142	141.5	142	143
15.....	132	135	127	135
17.....	148-150	148-150	148-150	148-150

15. Iodine Number—Hanus Method.

1.....	187.5	184.3	186.9	185.5
3.....	186.8	183.2	186.8	185.0
4.....	184.2	182.9	182.5	184.1
6.....	186.8	183.7	185.7	187.0
7.....	190.0	186.9	191.2	188.6
8.....	189.3	186.0	188.4	186.1
9.....	185.8	183.3	186.5	185.1
12.....	182.3	183.3	184.7	182.6
15.....	180.8	177.2	179.2	177.5
17.....	192.7	184.2	186.3	188.7
22.....	189.9	186.0	189.5	187.6
24.....	187.0	185.7	181.9	185.8
25.....	184.3	183.4	185.5	183.3
26.....	188	186	183	189

The foregoing tabulation shows the following results as far as it has been considered wise to average them:

Sample No.	1.	2.	3.	4.
1a. Sp. gr. at 15.5° C.....	0.9347	0.9331	0.9331	0.9344
1b. " " " 25° "	0.9298	0.9284	0.9285	0.9295
2. Turbidity and foots, in c. c.	0.76	0.35	0.40	0.65
4. Moisture and volatile matter				
a	0.056	0.088	0.150	0.025
b	0.047	0.058	0.184	0.052
5. Ash.....	0.140	0.026	0.039	0.154
8. Acid number	1.15	3.50	1.94	1.58
9. Saponification number ..	190.6	190.1	190.1	190.2
10a. Unsaponifiable matter ...	0.99	0.96	0.99	0.98
12. Refractive index	1.4800	1.4794	1.4797	1.4797
15. Iodine number	187.9	184.5	186.1	186.0

In the main, the specifications for analysis, etc., submitted by the Committee, have proven satisfactory.

We would recommend that, provisionally, the methods given relating to specific gravity, acid number, saponification number, unsaponifiable matter, refractive index, and iodine number, be considered standard, and that a raw linseed oil shall be considered pure when it tests between the following:

	Maximum.	Minimum.
Specific gravity at 15.5° C.....	0.936	0.932
" " " 25° C.....	0.931	0.9270
Acid number	6.00	.....
Saponification number	192	189
Unsaponifiable matter, per cent.....	1.50	.....
Refractive index at 25° C.....	1.4805	1.4790
Hanus iodine number	190	178

These tests and specifications are advised simply for consideration during the coming year. They should be subjected to further rigid examination by your Committee and be made to run the gauntlet of the most severe criticism before their formal adoption.

While the tests for turbidity, moisture and volatile matter, ash, and the Liebermann-Storch test, show interesting results, we do not feel that we are warranted at the present time in offering them as provisionally standard. Further work will have to be done on these tests in order that they may be brought to a position of real value.

Much work must still be done to develop suitable tests for the

"drying coefficient" of linseed, if we may coin that expression. The "drying test on glass" gave such varied results that it would appear to be worthless as specified by your Committee. Some better method should be found to determine the drying rate (or "coefficient") of linseed oil.

The oxygen absorption test, using litharge as the agent, does not give results as satisfactory as are desired. Your Committee should do more work in reference to this test. The acetyl value and hexabromide tests also deserve special consideration, with the hope that new and better methods may be devised.

As your Committee has in reserve other portions of these samples of oil, carefully sealed, it is in a position to send out further samples without great difficulty or delay, so that the work suggested above can be carried out with promptitude.

Many other lines of work suggest themselves to your Committee, of which the following are the more important:

1. Development of other tests, including flash point, etc.
2. Examination of linseed oil produced from new and old seed, to discover what difference ageing of seed may have on oil.
3. Examination of oil from damaged and off-grade seed.
4. Examination of boiled oil.

Letters of regret have been received from the following analysts, explaining their failure to report.

Unable to make the analyses owing to stress of other duties:

11. A. J. Patten, Lansing, Mich.
13. J. E. Greaves, Logan, Utah.
14. E. F. Ladd, Fargo, North Dakota.
21. Paul Schweitzer, University of Missouri, Columbia, Mo.
27. Otto Eisenschimml, American Linseed Company, South Chicago, Ill

Various reasons:

5. S. S. Voorhees, Engineer of Tests, Department of the Interior, U. S. Geological Survey, Washington, D. C.
The samples were lost in the fire.
10. H. H. Knisely, 310 Worcester Building, Portland, Oregon.
Did not receive the samples.
16. J. C. Dickerman, Madison, Wis.
Has not yet completed the work.
19. J. S. Jones, Moscow, Idaho.
Could not report on time.

It is hoped that their reports, coming in later, will help the work of your Committee during the coming year.

The thanks of the Society should be especially tendered to the National Lead Co., the Hirst and Begley Co., the American Linseed Co., and the Archer-Daniels Co., for the samples of linseed oil which they contributed, and for their general assistance in the work of the Committee; also to the members of the sampling committees, and to the analysts who have given so much of their time to the testing of the samples of oil.

Respectfully submitted,

G. W. THOMPSON,
Chairman, Sub-Committee on Linseed Oil.

The final work of the Committee has been undertaken in cooperation with Committee U on Corrosion of Iron and Steel. The full report of this Joint Committee is presented as Appendix II to this report.

In continuing the work of the Committee for the ensuing year, it is felt that a study of the underlying cause of the action of pigments on corrosion will be of much value. The field is a broad one and will require much careful investigation.

It is also the desire of the Committee to continue its study of the physical character of detached films and the relation of the size of pigment particles to strength and permeability.

It is further hoped that opportunity will be afforded the Committee to conduct additional service tests with white paints on wooden surfaces. The magnitude and the importance of the general class of house paints is so vital to the building interests of the entire country, that the report of this Committee must be based on very positive data.

Respectfully submitted on behalf of the Committee,

S. S. VOORHEES,
Chairman.

J. F. WALKER,
Secretary.

APPENDIX I.

COMPLETE REPORTS OF ANALYSTS.

REPORT OF G. W. THOMPSON.

Laboratory of the National Lead Company.

I submit, herewith, my report on the examination of the four samples of pure linseed oil sent by you. The analyses were performed by E. J. Sheppard, of this laboratory, under my supervision.

In all this work the 1909 atomic weights were used. Wherever the method employed differed from that prescribed in the circular, the modified method is given.

1a. SPECIFIC GRAVITY AT 15.5° C.

A calibrated 50-c. c. pyknometer was used for all specific gravity determinations.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9346		0.9338	0.9346
0.9346	0.9338	0.9338	0.9345
0.9345	0.9338	0.9337	0.9346
<hr/>	<hr/>	<hr/>	<hr/>
0.9346	0.9338	0.9338	0.9346

1b. SPECIFIC GRAVITY AT 25° C.

	0.9285	0.9286	
0.9298	0.9285	0.9284	0.9294
0.9299	0.9284	0.9286	0.9294
<hr/>	<hr/>	<hr/>	<hr/>
0.9298	0.9285	0.9286	0.9294

2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

Ordinary glass tubing was sealed at one end, and 25 c. c. of the oil were added. After standing two weeks, the height of the column of foots was marked on the tube, the oil poured out, and the tubes cleaned. Water was run in from a burette and the reading obtained from the burette.

0.75	0.10	0.65	0.65
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3. BREAKING TEST.

Breaks at 260° C. Does not break. Does not break. Breaks at 265° C.

11. *Liebermann-Storch Test—Colors.*

Analyst.	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1....	Green	Green	Slight green	Slight green
3....	Pale green	Pale green	Pale green	Pale green
6....	Negative	Negative	Negative	Negative
7....	"	"	"	"
8....	"	"	"	"
9....	Dark brown	Dark brown	Blackish brown	Blackish brown
12....	Negative	Negative	Negative	Negative
15....	"	"	"	"
17....	"	"	"	"
22....	"	"	"	"
25....	"	"	"	"
26....	"	"	"	"
30....	"	"	"	"

12. *Refractive Index at 25° C.*

1....	1.4799	1.4790	1.4793	1.4793
3....	1.4805	1.4793	1.4795	1.4798
4....	1.4805	1.4803	1.4802	1.4801
6....	1.4805	1.4800	1.4800	1.4800
7....	1.4794	1.4794	1.4798	1.4800
8....	1.4802	1.4798	1.4802	1.4801
9....	1.4800	1.4796	1.4799	1.4799
15....	1.4796	1.4792	1.4790	1.4783
17....	1.4798	1.4793	1.4796	1.4798
22....	1.4797	1.4795	1.4795	1.4795
24....	1.4800	1.4794	1.4795	1.4797
25....	1.4780	1.4772	1.4775	1.4775
26....	1.4799	1.4795	1.4800	1.4800

13. *Acetyl Value.*

1.....	26.4	24.4	27.1	21.6
3.....	4.1	4.2	4.1	5.7
7.....	11.7	9.9	7.8	7.9
9.....	29.95	29.08	29.13	29.11
17.....	27.05	12.9	21.7	19.8
24.....	14.8	14.8	12.0	12.7
25.....	5.42	6.20	6.30	4.78
	4.63	5.40	4.41	5.43
26.....	21.4	27.8	25.0	30.5

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Litharge.—Sample A.—Portion of colormaker's litharge passing through a 100-mesh screen but not passing through No. 21 cloth.

B.—Portion of colormaker's litharge passing through 100-mesh screen and also through No. 21 cloth.

TABLE II.

Number.	Litharge.		Oil.	Increase in per cent. in — hours.			
	Sample.	Weight, grams.		24.	48.	72.	96.
1	D	5	Raw	1.35	none	8.40	12.16
2	"	10	"	0.32	0.69	2.00	9.62
3	E	5	"	5.47	9.00	9.33	9.55
4	"	10	"	8.70	15.71	16.12	16.26

C.—Special fine litharge similar to that sent out by Committee.

D.—Sample received from P. H. Walker.

E.—Committee E sample.

The oil used in all cases was about 0.5 gram accurately weighed.

TABLE III.—TEN GRAMS LITHARGE, SAMPLE E.

Number	Sample Oil, No.	Increase in per cent. in — hours.				
		24.	48.	72.	96.	120.
1	1	16.33	18.02	....	18.40	18.68
2	"	17.56	19.20	....	19.52	19.67
3	"	17.54	19.22	....	19.43	19.59
4	"	18.94	20.01	....	....	20.61
5	"	18.26	19.29	....	....	19.50
6	"	17.42	18.71	....	....	19.24
7	2	16.93	18.51	....	....	18.90
8	"	15.95	17.77	....	....	18.17
9	"	16.43	18.06	....	....	18.38
10	"	17.76	18.66	....	....	19.33
11	"	17.24	18.16	....	....	18.82
12	"	18.42	19.45	....	....	20.24
13	3	15.79	16.79	17.65	....	18.10
14	"	15.30	17.37	....	....	17.73
15	"	13.67	15.98	16.05	....	16.65
16	"	16.17	18.38	....	....	18.96
17	"	15.09	17.65	....	....	17.88
18	"	13.70	16.99	....	....	17.42
19	4	14.68	17.27	17.45	....	18.02
20	"	13.59	16.24	16.55	....	17.24
21	"	14.24	16.88	17.07	....	17.62
22	"	14.25	17.96	....	....	18.56
23	"	13.45	17.44	....	....	18.07
24	"	13.89	18.17	....	....	18.83

All samples of linseed oil were of known purity.

For all determinations $2\frac{1}{2}$ -in. glass dishes were used.

From Table I it will be seen that the difference in size of the oxide particles had little influence upon the absorption; also, that 5 grams of litharge was insufficient for a complete absorption of oxygen in a minimum time even with boiled oil.

The use of 10 grams of litharge naturally suggested itself, with the result as indicated in Table I—that the use of 10 grams of PbO is productive of a more complete oxygen absorption in a minimum time.

As shown in Table II, sample D as well as the 5-gram charge of E, gave results too low to be considered.

The figures obtained indicate that for a comparative test the same variety of litharge should be used and that the absorption equilibrium is more quickly established with 10 grams than as recommended in Bulletin 109 of the Department of Agriculture, Bureau of Chemistry.

Committee Samples.—Table III contains the result obtained on the litharge E and the committee samples of oil. After 120 hours none gained appreciably; the majority, however, lost slightly.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
19.54	18.97	17.79	18.05

No determinations have been omitted.

8. ACID NUMBER.

(Expressed in milligrams of KOH per gram of oil.)

0.994	2.832	1.67	1.46
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9. SAPONIFICATION NUMBER.

(Expressed as in 8.)

189.5	191.3	190.7	
190.5	191.2	190.7	190.9
190.2	191.05	190.8	191.1
<hr/>	<hr/>	<hr/>	<hr/>
190.1	191.2	190.7	191.0

10. PERCENTAGE OF UNSAPONIFIABLE MATTER.

The lubricant was entirely removed from all stoppers and cocks of the separatory funnels.

0.85	0.94	0.96	0.86
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11. LIEBERMANN-STORCH TEST.

Negative.	Negative.	Negative.	Negative.
Green.	Green.	Slight green.	Slight green.

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12. REFRACTIVE INDEX AT 25° C.

The refractometer was standardized on water at 25° C., using the constant temperature apparatus.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4799	1.4790	1.4793	1.4793

13. ACETYL VALUE.

(Expressed in milligrams of KOH per gram of oil.)

Series (a).

The oil was boiled with acetic anhydride in an Erlenmeyer flask, using a funnel as condenser. An excess of 2 c. c. of standard acid was used to liberate the fatty acids. This solution was not heated but the acids allowed to separate gradually.

42.4	37.6	34.8	42.3
	39.8	45.2	34.6

Series (b).

The oil was filtered directly into a small, round-bottomed flask and an equal volume of acetic anhydride added. The mixture was boiled several hours with frequent shaking. A long tube acted as a condenser. The rest of the method was carried out as in Series (a).

26.4	24.4	27.1	21.6
26.6	21.5		

The water used for washing the fatty acids was first vigorously boiled to free it from carbon dioxide, special care being taken to make this operation complete.

14. HEXABROMIDE TEST, IN PER CENT.

30.3	30.87	29.55	19.84
30.6	28.91		
25.3			

15. IODINE NUMBER.

187.3	184.1	186.87	185.3
187.4	184.3	186.80	185.9
187.9	184.5	186.90	185.2
<hr/>	<hr/>	<hr/>	<hr/>
187.6	184.3	186.90	185.5

The standardization of the potassium bichromate gave a figure slightly higher than on re-sublimed iodine.

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REPORT OF P. H. WALKER.

Contracts Laboratory, U. S. Department of Agriculture.

(Chemical work done by Mr. E. W. Boughton.)

1a. SPECIFIC GRAVITY AT 15.5° C.

(Determined with pycnometer.)

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9342	0.9327	0.9326	0.9341

1b. SPECIFIC GRAVITY AT 25° C.

0.9298	0.9283	0.9283	0.9296
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.8	0.5	0.5	0.5
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3. BREAKING TEST.

Breaks.	Does not break.	Does not break.	Breaks.
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4a. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

(To constant weight at 105° C. in CO₂.)

0.10	0.12	0.33	0.09
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4b. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

(2 hours in steam oven.)

0.09	0.09	0.26	0.08
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5. PERCENTAGE OF ASH.

0.20	Trace	0.03	0.19
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6. DRYING TEST ON GLASS IN DAYS.

(Temperature 20° to 25° C.)

7.5	4.5	4.5	7.5
8	4	6	7.5

7. OXYGEN ABSORPTION WITH PbO.*

(Set 1) Committee PbO—5 grams PbO and 0.5 gram oil.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
0.02	24	4.70	24	0.30	24	0.20	24
0.8	48	6.5	48	3.5	48	1.5	48
1.5	72	7.1	72	4.9	72	3.9	72
3.1	96	8.0	96	6.5	96	8.1	96
7.4	120	8.1	120	7.9	120	11.0	120

* Sets 1 and 1a were run at the same time; sets 2 and 2a were also run simultaneously, but not at the same time as sets 1 and 1a.

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7. OXYGEN ABSORPTION WITH PbO (CONTINUED).

(Set 1a) *Committee PbO*—10 grams PbO and 0.5 gram oil.

Sample No. 1.		Sample No. 2.		Sample No. 3.		Sample No. 4.	
Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
0.4	24	10.6	24	1.8	24	0.8	24
2.2	48	11.2	48	10.4	48	10.2	48
4.9	72	12.0	72	13.1	72	14.0	72
10.9	96	12.8	96	15.2	96	15.1	96
15.5	120	13.2	120	15.3	120	15.3	120

(Set 2) *Committee PbO*—5 grams PbO and 0.5 gram oil.

3.0	24	6.1	24	2.9	24	1.0	24
5.0	48	7.5	48	6.8	48	4.0	48
12.9	72	8.4	72	8.7	72	7.6	72
15.3	120	11.8	120	9.6	120	8.6	120

(Set 2a) *Bureau of Chemistry PbO*—5 grams PbO and 0.5 gram oil

2.2	24	9.8	24	8.8	24	5.1	24
9.1	48	11.0	48	11.4	48	10.4	48
13.0	72	11.6	72	13.1	72	13.3	72
14.6	120	11.9	120	13.3	120	14.2	120

8. ACID NUMBER.

1.0	3.4	1.8	1.5
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9. SAPONIFICATION NUMBER.

190.2	190.6	190.2	190.1
-------	-------	-------	-------

10a. UNSAPONIFIABLE MATTER.

1.08	1.03	1.02	1.08
Microscopic examination of phytosterol.	Examination by Mr. B. J. Howard.	Hexagonal plates characteristic of phytosterol.	No indication of cholesterol.

10b. UNSAPONIFIABLE MATTER.

(Melting point of phytosterol acetate in degrees Centigrade.)

126	126	128	127
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Second crystallization. Readings made to 1° C.
Corrected for stem correction.

11. LIEBERMANN-STORCH TEST.

Pale green.	Pale green.	Pale green.	Pale green.
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12. REFRACTIVE INDEX AT 25° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4805	1.4793	1.4795	1.4798

13. ACETYL VALUE.

4.1	4.2	4.1	5.7
-----	-----	-----	-----

14a. HEXABROMIDE TEST.

(Bromine Precipitate.)

		44.1	
42.6	40.9	40.3	
46.5	39.9	47.2	43.9
43.0	37.3	46.6	38.5
<hr/>	<hr/>	<hr/>	<hr/>
44.0	39.3	44.5	41.2

14b. MELTING POINT OF BROMINE PRECIPITATE.

(Degrees Centigrade.)

150	151	149	150
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(Readings made to 1° C. Corrected for stem correction.)

BROMINE IN BROMINE PRECIPITATE (PER CENT.).

57.2	57.7	57.4	57.7
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15. IODINE NUMBER.

(Acetic acid 99.5 per cent.—Melting point method.)

186.8	183.2	186.8	185.0
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REPORT OF A. H. GILL.

Massachusetts Institute of Technology, Boston.

7. DRYING TEST ON LITHARGE.

(a) 5 grams PbO.

	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
48 hours.	2.3	7.9	6.0	5.1
	1.2			
1 week.	1.5	9.5	10.8	9.1

(b) 10 grams PbO.

48 hours.	1.5	13.2	13.4	5.9
1 week.	14.4	13.3	15.1	14.4
	19.0			

8. ACID NUMBER.

0.9	3.3	1.1	1.4
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12. REFRACTIVE INDEX.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4805	1.4803	1.4802	1.4801

14. HEXABROMIDES, PER CENT.

26.20	19.4	11.8	14.2
24.9	19.1	12.0	14.2

15. IODINE NUMBER.

184.2	182.9	182.5	184.1
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REPORT OF GLENN H. PICKARD.

Spencer Kellogg Company, Buffalo, N. Y.

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9344	0.9313	0.9319	0.9330

1b. SPECIFIC GRAVITY AT 25° C.

0.9284	0.9268	0.9271	0.9280
--------	--------	--------	--------

2. TURBIDITY AND FOOTS.

In making the turbidity and foots test, we first chilled one portion of the sample to 16° F. Then we took another portion of the sample and heated it to 180° F., and took another one right out of the bottle just as we received it. These were then put in a rack, side by side, and the test continued as directed with the following results:

Chilled to 16° F.

Per cent.	per cent.	Per cent.	Per cent.
5.5	2.5	3.5	5.25

Normal.

2.75	2	2	2.5
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Heated to 180° F.

2.5	None	0.5	2
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You perhaps may have noticed in the writer's article, as published in the *Painter's Magazine*, that he stated that a good deal of material which is termed foots is in reality not that substance at all, but some other, the exact composition of which we can only surmise, which separates when the oil is chilled. The writer is inclined to the idea that it is the high melting point fats which crystallize under the conditions existing when the temperature is reduced. The result of this test would seem to be additional proof to this statement, because the chilled oil is in every case higher while the oils in which we should expect to find none of the mucilaginous or other matter which is normally called foots, show almost

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none when that sample has been heated up to 180° F., and not allowed to chill again during the period in which the sediment is forming. And yet, from this same oil when it is chilled there is a precipitate which looks and acts very much like the material normally termed foots by the linseed oil consuming trade.

This is a bit of data which we thought might be of interest to you, and possibly of interest enough to bear incorporation in the report.

3. BREAKING TEST.

Sample No. 1. Broke.	Sample No. 2. Did not break.	Sample No. 3. Did not break.	Sample No. 4. Broke.
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5. PERCENTAGE OF ASH.

0.135	0.033	0.06	0.17
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7. OXYGEN ABSORPTION.

(a) 5 grams PbO.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
16.6	144	12.7	—	13.5	—	13.6	—

(b) 10 grams PbO.

14.6	144	14.4	96	14.6	96	14.5	96
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These are all the results which we have been able to get, owing to lack of time, and in one instance to the fact that we did not have the proper dessicator to keep the relative humidity of the drying atmosphere the same at all times.

8. ACID NUMBER.

1.2	3.65	2.2	1.75
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9. SAPONIFICATION NUMBER.

188.6	189.6	189.2	189.7
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11. LIEBERMANN-STORCH TEST.

The Liebermann-Storch Test for rosin or rosin oil was negative in each instance.

12. REFRACTIVE INDEX AT 25° C.

1.4805	1.4800	1.4800	1.4800
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15. IODINE NUMBER.

186.8	183.7	185.7	187.0
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REPORT OF H. M. LOOMIS.

Acting Chief, Food and Drug Inspection Laboratory,
Seattle, Wash.

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9342	0.9331	0.9329	0.9341

1b. SPECIFIC GRAVITY AT 25° C.

0.9297	0.9280	0.9283	0.9297
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.70	0.25	0.25	0.70
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3. BREAKING TEST.

Breaks at 250-270° C.	Does not break.	Does not break.	Breaks at 250-265° C.
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4b. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

0.052	0.041	0.212	0.056
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5. PERCENTAGE OF ASH.

0.14	0.025	0.034	0.149
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6. DRYING TEST ON GLASS IN HOURS.

(Made in laboratory near east window.)

80	67	115	93
(2 tests)	71	91	84
		87	

7. OXYGEN ABSORPTION.

(a) 5 Grams Litharge.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
3.32	48	5.30	48	4.32	48	6.49	48
5.77		8.05		7.41		7.85	
		6.73					

(maximum.)

11.03	118	9.92	93	8.70	95	10.06	93
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(b) 10 Grams Litharge.

12.8	48	10.74	48	10.21	48	10.95	48
		11.85		12.6			

(maximum.)

14.73	118	13.58	93	14.0	95	14.95	93
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8. ACID NUMBER.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.18	3.57	1.98	1.71

9. SAPONIFICATION NUMBER.

(Run $\frac{1}{2}$ hour.)

192.2	191.4	190.8	190.4
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10a. PERCENTAGE OF UNSAPONIFIABLE MATTER.

1.15	0.83	1.41	1.71
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10b. MELTING POINT OF ACETATE FROM UNSAPONIFIABLE MATTER.

125.5	120	126	121
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11. LIEBERMANN-STORCH TEST.

Dark green, turning quickly to brownish- black.	Dark brown, turning darker and more opaque.	Blackish brown, turning darker.	Blackish brown, turning darker.
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12. REFRACTIVE INDEX AT 25° C.

1.4800	1.4796	1.4799	1.4799
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15. IODINE NUMBER.

(Standing $\frac{1}{2}$ hour.)

185.8	183.3	186.5	185.1
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ODOR AND TASTE.

Sample No. 1.

Appearance.—Orange yellow with slight flocculent white sediment.
Odor and Taste.—Nutty.

Sample No. 2.

Appearance.—Orange yellow color, but little lighter than No. 1, with sediment as in No. 1.
Odor and Taste.—Nutty.

Sample No. 3.

Appearance.—Same as No. 2.
Odor.—Resembling mineral oil.
Taste.—Slight, resembling mineral oil.

Sample No. 4.

Appearance.—Brownish yellow color. Slight sediment.
Odor.—Nutty.
Taste.—Nutty and slightly bitter.

ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. 179

NOTES.

Hexabromide Test.—Followed Tolman's method as given, except that Babcock cream bottles were used instead of weighing bottles. In working the hexabromide precipitate, stirring rods were not used; simply shaking flask and contents with the other served to detach the precipitate from the flask and insure thorough washing. The result on this test was very unsatisfactory, although great care was taken to carry out the test uniformly. Seven determinations were run on each oil and while the four results on each series were quite concordant, I obtained results varying from 20 to 58 per cent. Lack of time made it impossible for me to find the cause of this wide variation.

ADDITIONAL REPORT FROM H. M. LOOMIS.

Thinking it may be of interest to you to have my results on the acetyl value and hexabromide test, I am sending them herewith, and you may publish them or not as you see fit.

13. ACETYL VALUE.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
29.95	29.08	29.13	29.11

14. HEXABROMIDE TEST, IN PER CENT.

Bromine was added drop by drop from a burette, cooling in ice and water mixture between each addition.

46.3	39.3	42.3	35.6
27.7	21.6	27.1	22.9
34.7	34.1	34.6	32.6
48.1	44.1	43.9	46.0
26.5	20.0	25.6	26.5
34.6	29.9	39.1	35.0

REPORT OF S. R. MITCHELL.

New Mexico College of Agriculture and Mechanic Arts, New Mexico.

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9344	0.9325	0.9336	0.9343

1b. SPECIFIC GRAVITY AT 25° C.

0.9303	0.9287	0.9284	0.9291
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A 50-c. c. pycnometer was used.

2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.60	0.65	0.75	0.50
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A graduated test tube was used.

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3. BREAKING TEST.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
No break.	No break.	No break.	Broke at 280°.

4b. MOISTURE AND VOLATILE MATTER.

Same.	0.002 gram gain.	0.0085 gram loss.	Same.
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The heating was done in a steam-jacketed oven at boiling point of water, which at this altitude is 97° C. Determinations were also made on filtered oil with the following results:

0.001 gram gain.	0.0025 gram gain.	0.006 gram loss.	0.0005 gram loss.
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5. PERCENTAGE OF ASH.

0.135	0.035	0.05	0.145
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The percentage of ash on No. 4 may be a little high. A muffle was used on all. Ash determinations were also made on the filtered oil of three samples with following results:

0.13	0.03	0.04
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8. ACID NUMBER.

1.26	3.36	1.89	1.54
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9. SAPONIFICATION NUMBER.

190.78	191.18	191.18	190.01
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The contents of the flasks were allowed to simmer (not boil) for 30 minutes. At first the boiling method was tried, but the contents boiled over and spoiled the results.

11. LIEBERMANN-STORCH TEST.

No rosin.	No rosin.	No rosin.	No rosin.
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15. IODINE NUMBER.

182.3	183.3	184.7	182.6
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REPORT OF F. S. KEDSIE.

Michigan Agricultural College, East Lansing, Mich.

The following is the work done on the four samples of linseed oil by Prof. H. S. Reed of this department. All of the tests were carefully made, but none in duplicate, and the report therefore represents the work of an experienced man in applying the tests as laid down.

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1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.935620	0.934866	0.934634	0.935188

1b. SPECIFIC GRAVITY AT 25° C.

0.928704	0.926424	0.926726	0.929130
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.6	0.2	0.25	0.55
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3. BREAKING TEST.

0	0	0	Broke.
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4b. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

(Drying in oven at 100° C.)

a.	0.756	0.534	0.0488	0.491
b.	0.09693	0.03714	0.1656	0.1175

5. PERCENTAGE OF ASH.

(On filtered sample.)

0.125	0.03	0.03	0.131
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6. DRYING TEST ON GLASS.

(Not satisfactory.)

7. OXYGEN ABSORPTION.

(Per cent. gain in 48 hours at 75° F. Glass dishes used.)

6.479	6.477	6.411	7.598
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8. ACID NUMBER.

1.12	3.77	2.17	1.69
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9. SAPONIFICATION NUMBER.

189.98	190.6	189.6	188.7
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10a. PERCENTAGE OF UNSAPONIFIABLE MATTER.

0.99	0.975	1.052	0.987
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10b. UNSAPONIFIABLE MATTER.

(Results obtained on 4 samples.)

Crystals of phytosterol plainly discernible. No evidence of cholesterol. Melting point of phytosterol acetate, 128-130° C.

11. LIEBERMANN-STORCH TEST.

0	0	0	0
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12. REFRACTIVE INDEX.

(Using Zeiss Butyro-Refractometer.)

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4798	1.4793	1.4796	1.4798

13. ACETYL VALUE.

(Milligrams of KOH required to saponify 1 gram acetylated oil.)

27.05 ?	12.9 ?	21.7 ?	19.8 ?
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14a. HEXABROMIDE TEST, PER CENT.

(According to Hehner and Mitchell.)

56.6	49.3	48.1	48.2
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14b. MELTING POINT OF BROMIDES.

All four samples melted between 148° and 150° C.

15. IODINE NUMBER.

192.7	184.2	186.3	188.7
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REPORT OF E. J. SHANLEY.

Food and Drug Inspection Laboratory, Chicago, Ill.

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9342	0.9329	0.9330	0.9339

1b. SPECIFIC GRAVITY AT 25° C.

0.9289	0.9274	0.9277	0.9289
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.9	0.3	0.4	0.8
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3. BREAKING TEST.

(300°.)

Breaks.	No break.	No break.	No break.
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4a. PERCENTAGE OF MOISTURE AND VOLATILE MATTER IN HYDROGEN.

0.04	0.02	0.06	None.
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4b. PERCENTAGE OF MOISTURE AND VOLATILE MATTER IN AIR.

None.	None.	0.19	0.03
0.004	Gained.	0.13	None.

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5. PERCENTAGE OF ASH.			
Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.14	0.03	0.03	0.16
0.14	0.02	0.05	0.16
6. DRYING TEST ON GLASS IN HOURS.			
72	75	72	72
7. OXYGEN ABSORPTION, USING LEAD MONOXIDE.			
(a) 5 grams PbO.			
Per cent.	Per cent.	Per cent.	Per cent.
13.10	10.69	10.59	10.76
(b) 10 grams PbO.			
15.16	14.09	13.96	14.44
8. ACID NUMBER.			
1.2	3.73	2.07	1.66
9. SAPONIFICATION NUMBER.			
191.31	191.23	191.10	190.90
10a. UNSAPONIFIABLE MATTER.			
0.97	1.03	0.98	1.12
11. LIEBERMANN-STORCH TEST.			
Negative.	Negative.	Negative.	Negative.
12. REFRACTIVE INDEX.			
1.4797	1.4795	1.4795	1.4795
14a. HEXABROMIDE TEST.			
40.89	39.67	40.49	40.03
15. IODINE NUMBER.			
189.82	186.09	189.19	187.48
190.05	186.03	189.85	187.79

In the drying test on glass, the slides were left standing on a laboratory table, no special precautions to have a 25 per cent. saturated atmosphere being taken.

The figures for the oxygen absorption test were taken after standing for 4½ days. The last two weighings were very nearly constant. If you wish any of the results duplicated, or if you desire any other further information concerning the samples, I shall be ready to carry out your suggestions.

REPORT OF C. E. WATERS.
Bureau of Standards, Washington, D. C.
(Chemical Work done by Mr. J. B. Tuttle.)

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9338	0.9328	0.9326	0.9342
0.9337	0.9328	0.9322	0.9343
<hr/>	<hr/>	<hr/>	<hr/>
0.9338	0.9328	0.9324	0.9342

1b. SPECIFIC GRAVITY AT 25° C.

0.9299	0.9285	0.9286	0.9303
0.9298	0.9286	0.9287	0.9302
<hr/>	<hr/>	<hr/>	<hr/>
0.9298	0.9286	0.9287	0.9302

2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.71	0.14	0.21	0.64
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3. BREAKING TEST.

Yes.	No.	No.	Yes.
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4a. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

(Two grams of oil at 105° C. in an atmosphere of CO₂.)

0.01	0.05	0.14	0.00
0.01	0.07	0.12	0.05
0.00	0.03	0.22	0.01
0.10	0.03	0.06	0.03
<hr/>	<hr/>	<hr/>	<hr/>
0.03 gain.	0.05 loss.	0.13 loss.	0.02 loss.

4b. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

Five grams of oil at 100° C. in steam-jacketed oven. Petri dishes, 2½ ins. diameter, were not available, and aluminum dishes 2½ ins. square, (containing about the same area as 2½-in. round dish) were used instead.

0.014	0.018	0.123	0.035
0.018	0.008	0.138	0.045
0.019	0.012	0.112	0.072
0.012	0.014	0.139	0.054
<hr/>	<hr/>	<hr/>	<hr/>
0.016 loss.	0.013 gain.	0.128 loss.	0.052 loss.

5. PERCENTAGE OF ASH.

0.145	0.035	0.036	0.153
0.133	0.021	0.041	0.156
<hr/>	<hr/>	<hr/>	<hr/>
0.139	0.028	0.038	0.154

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6. DRYING TEST ON GLASS IN HOURS.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
30	30	30	30
Drying not yet complete.			

7. OXYGEN ABSORPTION.

(a) 5 grams PbO.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
5.46	48	8.11	48	8.38	48	7.46	48
6.23		7.88		9.01		8.39	

(b) 10 grams PbO.

13.65	120	13.40	240	12.09	120	13.32	120
13.79		13.20		13.29		13.68	

The following tests were also made. Test A was made using 5 grams of PbO furnished by the American Society for Testing Materials, while Test B was made with 5 grams Kahlbaum's C. P. Lead Monoxide.

A.	7.06	9.58	11.72	10.30
B.	14.51	13.41	12.95	13.96

8. ACID NUMBER.

1.17	3.71	2.06	1.71
1.14	3.79	2.07	1.69
<hr/>	<hr/>	<hr/>	<hr/>
1.15	3.75	2.06	1.70

9. SAPONIFICATION NUMBER.

(Using 5 grams oil, heating on steam bath 30 minutes.)

		189.7	
190.7	190.2	189.7	190.5
190.6	190.4	189.6	190.5
<hr/>	<hr/>	<hr/>	<hr/>
190.65	190.3	189.67	190.5

10a. PERCENTAGE OF UNSAPONIFIABLE MATTER.

The method used was that given in Bulletin 109, Bureau of Chemistry, using petroleum ether as the solvent.

0.90	0.57	1.03	0.91
	0.65	0.97	0.78
	0.81		
	<hr/>	<hr/>	<hr/>
	0.68	1.00	0.84

11. LIEBERMANN-STORCH TEST.

This test gave negative results in each case.

12. REFRACTIVE INDEX.

(Using Abbé Refractometer at 28° C.)

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4780	1.4772	1.4775	1.4775

13. ACETYL VALUE.

5.42	6.20	6.30	4.78
4.63	5.40	4.41	5.43

14. HEXABROMIDE TEST.

The method given in the circular of March 1 was closely adhered to, the only difference being that the determinations were made in glass weighing bottles, 1½ ins. diameter and 4 ins. high.

41.1	36.7	38.6	43.0
41.0	41.1	39.3	43.4
	48.8		

15 IODINE NUMBER.—HANUS METHOD.

185.4	183.7	185.9	184.0
185.2	184.0	186.2	182.6
184.6	183.4	185.9	183.2
184.5	184.0	185.3	
183.3	182.6	184.9	
184.6	182.4	185.1	
183.8			
183.3			
<hr/>			
184.3	183.4	185.5	183.3

REPORT OF ARTHUR D. LITTLE, INC.

Laboratory of Engineering Chemistry,
93 Broad Street, Boston, Mass.

In accordance with your circular letter of February 9, we have analyzed the four samples of linseed oil submitted by your Committee and prepared in conformance with its specifications, and present herewith our report. The samples were received sealed and in good condition, and the methods used were those recommended in your circular letter. All tests were made upon oil freshly filtered through dry filter paper immediately before use, at a temperature between 60° and 80° F., unless otherwise noted.

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1. SPECIFIC GRAVITY.

The specific gravity was determined by Ostwald pyknometers of the well-known type holding about 10 c. c. Although the Committee recommended that a pyknometer should be used "having a capacity of at least 25 c. c.," our experience has been that more accurate results can be obtained with a pyknometer of the Ostwald type having a capacity of 10 c. c., than with a much larger one of the ordinary bottle type. The temperature factor is the greatest cause of error, and if that could be eliminated, results could be obtained with such a pyknometer accurate to five decimal places. With a small pyknometer, moreover, less oil is forced out of the arms when it is allowed to come to room temperature from 15.5° C. before weighing.

The pyknometer was thoroughly cleaned with chromic acid solution, then rinsed out successively with water, alcohol, and ether, and dried by aspirating through it a current of dry air. Before every weighing it was wiped with a moist cloth and allowed to stand 15 minutes under a bell jar containing a dish of concentrated H_2SO_4 . After weighing empty, it was filled with pure distilled water and placed in a large water bath at 15.5° C., and allowed to remain there one hour. The water was frequently stirred and the bulb of the thermometer was within a fraction of an inch of each pyknometer. For every determination two pyknometers were used. After the weight of water at 15.5° C. had been obtained, the bath was raised to 25° C., the pyknometers allowed to remain one hour in the water at this temperature, and after adjusting the meniscus they were removed, wiped, allowed to stand 15 minutes, and weighed.

The pyknometers were then completely dried as described, and filled with freshly filtered oil. The weight of the oil at 15.5° C. was determined in exactly the same manner as that of the water.

The average difference in the results obtained by the two pyknometers is only 0.0003, and the mean results are probably correct to 0.0002.

STANDARDIZATION OF PYKNOMETERS.

(At 15.5° C.)

Pyknometer.	Average of two.
A.....	9.9997
B.....	11.0291

(At 25° C.)

A.....	9.9882
B.....	11.0124

(a) SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9355	0.9333	0.9336	0.9349
0.9350	0.9336	0.9336	0.9356
0.9352	0.9335	0.9336	0.9352

(b) SPECIFIC GRAVITY AT 25° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9299	0.9284	0.9286	0.9299
0.9301	0.9288	0.9288	0.9300
<hr/>	<hr/>	<hr/>	<hr/>
0.9300	0.9268	0.9287	0.9300

2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

After a thorough shaking, 25 c. c. of each sample were introduced by means of long-stemmed funnels into graduated glass tubes about 1 cm. in diameter. The tubes were then stoppered with corks and placed in a vertical position in a light place for two weeks. At the end of that time there was a sediment in the bottom of each tube, as follows:

0.80 0.25 0.30 0.55

The stoppers were then removed and the tubes allowed to stand unstoppered for two weeks more. No change was visible.

NOTE.—The sediment from samples Nos. 2 and 3 was gelatinous and would not form a sharp meniscus.

3. BREAKING TEST.

After a thorough shaking, 15 c. c. of each sample were slowly heated in a test tube over a naked flame. A Fahrenheit thermometer was suspended in the oil, and the rise in temperature was less than 90° F. (50° C.) per minute. Each sample was heated up to 572° F. (300° C.), and then the experiment was repeated with a fresh portion of oil.

Breaks about	Does not break	Does not break	Breaks about
265° C.	at 300° C.	at 300° C.	265° C.

4. MOISTURE AND VOLATILE MATTER.

(a) Loss at 105° C. in a current of CO₂.

The results of this experiment were unsatisfactory and are omitted.

(b) Loss at 100° C. for 2 hours in air.

Portions of about 5 grams of each sample, well shaken but not filtered, were placed in uncovered glass Petri dishes 2½ ins. in diameter and heated for 2 hours in a steam oven at 100° C. They were then cooled in a dessicator and weighed. The dishes had been previously heated in the same oven for 2 hours, cooled, and weighed. The results follow:

LOSS AT 100° C., IN PER CENT.

0.059	0.236	0.214	0.016
0.047	0.225	0.219	0.051
<hr/>	<hr/>	<hr/>	<hr/>
0.054	0.231	0.217	0.034

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In order to obtain consistent results it seems necessary to follow the foregoing directions very closely. The experiment was first attempted in shallow Petri dishes 4 ins. in diameter, and it was found that in some cases the oil gained in weight instead of losing. The thinness of the layer and the greater surface consequently exposed probably caused oxidation of the oil. The oil should be weighed as soon as cool, since it seems to have a tendency to oxidize in the dessicator after having been heated to 100° C..

5. PERCENTAGE OF ASH.

About 10 grams of each sample, thoroughly shaken but not filtered, were placed in large porcelain crucibles (previously ignited for 15 minutes) and burned to a light gray ash. After cooling the crucibles with the ash in dessicator, they were weighed. The results are tabulated below:

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.132	0.030	0.041	0.142
0.138	0.030	0.038	0.143
0.135	0.030	0.040	0.143

It will be noticed that samples Nos. 1 and 4, which show the highest ash, are the same which showed the greatest amount of turbidity. The ash is not alkaline to phenolphthalein.

6. DRYING TEST ON GLASS IN HOURS.

Archbutt's method as described by Gill in the circular of the Committee was followed exactly in preparing the glass plates coated with the oil. The coated plates were then placed under a bell-jar containing a beaker of concentrated sulphuric acid. They were examined several times during the day and the first thing in the morning, and the time was noted when the oil became dry to the touch.

140	120	100	160
-----	-----	-----	-----

7. OXYGEN ABSORPTION, USING LEAD MONOXIDE.

The method described in Bulletin 109, page 7, of the Department of Agriculture, Bureau of Chemistry, was followed as closely as possible. Not being able to obtain suitable dishes of aluminum, however, we used tin dishes of the prescribed size and shape. These were thinly coated on the inside with paraffine to prevent any contact of the tin with the lead monoxide. After the experiment, the paraffine was removed and the dishes were examined. Of the 16 dishes used, only 2 or 3 showed a few dark spots on the tin. Two sets of experiments were carried out: (a) using 5 grams of PbO; and (b) using 10 grams of PbO. The PbO was weighed out on a watch glass and placed in the dishes in as even and flat a layer as possible, completely covering the bottom of the dish. About 0.7 gram of the oil was then spread in drops as evenly as possible

over the surface of the PbO. The exact weight of oil was determined by the loss in weight of a dropping bottle containing the sample of freshly filtered oil. (It may be mentioned here that these dropping bottles were found very convenient in these experiments for weighing out exact quantities of oil from 0.1 to 5 or 10 grams. They are provided with a ground glass joint into which fits a dropper, easily filled and emptied by means of a small collapsible rubber nipple, on the principle of a fountain pen filler. The bottle holds about 1 fluid ounce and the dropper when filled delivers about 1 gram.) The dish with PbO and oil was then weighed exactly. Two dishes were prepared as above with each sample of oil and 5 grams of PbO, and two of each sample with 10 grams of PbO, respectively. They were all placed under a large sheet of plate glass, elevated about 1 in. above the table, having a free access of air in a light place. Each dish was weighed every morning and evening.

One dish of each sample (marked A in the following tables) was started in the morning and one of each sample (B in the tables) late in the afternoon, to determine whether the gain was as rapid in the dark as in the light. We give the results obtained and will discuss them later in this report. The figures represent the percentage of gain in weight based upon the weights of the oil taken.

(a) *With 5 grams of lead monoxide.*

TABLE I.—SET A, FIVE GRAMS PbO.

Sample No.	Weight of Oil, grams.	Gain in Weight in — Hours, per cent.										
		7	24	30½	46½	57	71	78½	95	106	120	100
1	0.6819	0.19	4.22	7.23	8.73	9.46	9.96	10.09	10.29	10.61	10.75	.....
2	0.8615	1.62	3.13	3.42	3.55	4.05	4.13	4.39	4.63	4.81	4.97	.....
3	0.6286	2.04	7.91	8.48	8.73	9.42	9.55	9.70	.....	.....	.....	11.24
4	0.7320	1.10	6.15	6.91	7.24	7.81	8.03	8.14	8.33	8.54	8.81	9.76

TABLE II.—SET B, FIVE GRAMS PbO.

Sample No.	Weight of Oil, grams.	Gain in Weight in — Hours, per cent.								
		7	24	41	51	65	72½	89	100	114
1	0.6731	1.77	5.70	8.20	8.72	8.72	.....	.....	.....	.....
2	0.7890	3.71	4.61	5.10	5.54	5.91	6.10	6.32	6.64	6.88
3	0.6311	6.20	7.58	8.20	8.81	8.97	9.18	9.16	.....	.....
4	0.6760	5.49	5.82	7.47	8.03	.....	.....	.....	.....	.....

In Table II, samples Nos. 1 and 3 were discontinued because they appeared to have reached a maximum, and No. 4 because of an accident. It will be noted that the gain in every case after about 60 hours had elapsed was very slow.

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These four tables show several interesting results. With 10 grams of PbO a definite maximum gain is obtainable, and with each sample this is reached in about 65 hours. The gain is slow at first and then very rapid, coming within 1 per cent. of the maximum in every case inside of 36 hours. With 5 grams of PbO the gain is also fairly rapid for the first 36 hours, although considerably less than when 10 grams of PbO are used; and after this period the oil continues to gain in weight very slowly for a long time. In view of the quick and consistent results obtained with 10 grams of PbO, it seemed to us hardly worth while to carry the experiments with 5 grams of PbO beyond 5 or 6 days. Two

(b) With 10 grams of Lead Monoxide.

TABLE III.—SET A, TEN GRAMS PbO.

Sample No.	Weight of Oil, grams.	Gain in Weight in — Hours, per cent.						
		6	23	29½	45	55	69	76½
1	0.6402	0.75	9.19	12.68	13.51	14.03*	13.75	.....
2	0.7991	1.82	11.16	11.70	12.12	12.56	12.84*	12.84
3	0.6430	0.75	11.30	11.81	12.55	12.83*	12.80	.....
4	0.6245	2.32	12.60	13.19	13.71	14.01	14.08*	.....

TABLE IV.—SET B, TEN GRAMS PbO.

Sample No.	Weight of Oil, grams.	Gain in Weight in — Hours, per cent.					
		17	24	41	51	65	72½
1	0.6578	3.19	10.45	13.30	13.87	14.02*	13.83
2	0.7323	10.81	12.00	12.43	12.80	13.04*	13.01
3	0.6862	10.26	12.32	12.83	13.07	13.20*	13.20
4	0.6674	9.95	11.90	12.40	12.90	13.00*	12.97

samples were allowed to run for 7 days, but at the end of that time they did not appear to have reached a maximum, and at the rate at which they were proceeding would have required several more days to have reached the maximum which the same samples showed with 10 grams of PbO in 2½ to 3 days.

The oil takes up oxygen more rapidly in the light than in the dark, as will be seen by comparing Tables III and IV. In Table III, three of the samples reached their maximum in 55 hours, of which 33 hours were light and 22 were dark. In Table IV, the samples reached practically the same maxima in 65 hours, of which 32 hours were light and 33 were dark. The samples in the latter table, as has been stated, were started late in the afternoon.

* Maximum

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In reporting our results we shall omit the experiments with 5 grams of PbO.

7b. OXYGEN ABSORPTION, 10 GRAMS PbO.

Sample No.	Maximum, Started in Morning—(A).		Maximum, Started in Evening—(B).	
	Time, hours.	Gain, per cent.	Time, hours.	Gain, per cent.
1	55 (about)	14.03	65 (about)	14.02
2	65 "	12.84	65 "	13.04
3	55 "	12.83	65 "	13.20
4	60 "	14.08	65 "	13.00

In our opinion the best method of applying this test in comparing different oils is to use 10 grams of PbO and about 0.7 gram of the oil. The test should then be allowed to run a definite length of time; and since the oxidation proceeds more rapidly in the light, it is sooner finished if started in the morning. Under these conditions the samples will have reached their maximum gain (within a few tenths of one per cent. at any rate) by the third afternoon, say in 55 hours. For all practical purposes of comparison, however, 48 hours will be sufficient, if the experiment is started in the morning. This is the length of time recommended in Bulletin 109. If started in the afternoon, they should be allowed to run somewhat longer.

8. ACID NUMBER.

The method described in Bulletin 107, page 142, of the Department of Agriculture, Bureau of Chemistry, was followed. The results are expressed in milligrams of KOH per gram of oil. The determinations were made on freshly filtered oil.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.24	3.57	1.94	1.74
1.16	3.58	1.96	1.68
<hr/> 1.20	<hr/> 3.57	<hr/> 1.95	<hr/> 1.71

9. SAPONIFICATION NUMBER.

About 5 grams of each freshly filtered sample were placed in a 300-c. c. Jena Erlenmeyer flask and saponified for one hour under a reflux condenser with 50 c. c. of alcoholic KOH. Two blanks were run with each set of determinations (A, B, and C, respectively). The blanks and samples were then titrated with $N/2$ H_2SO_4 , using phenolphthalein as an indicator.

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9. SAPONIFICATION NUMBER (CONTINUED).

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
192.8	192.8	191.7	194.1
193.8	193.2	193.0	194.3
193.5	193.4	193.3	194.8
<hr/>	<hr/>	<hr/>	<hr/>
193.4	193.1	192.7	194.4

The saponification number represents the number of milligrams of KOH required for 1 gram of the oil.

10. UNSAPONIFIABLE MATTER.

Boemer's method as described in the circular of the Committee was followed exactly, using freshly filtered oil.

The unsaponifiable matter was boiled with about an equal weight of acetic anhydride for 2 hours in a regular acetylation flask—a small oval-shaped flask having ground into the neck a long glass tube which serves as an air-cooled reflux condenser. The unsaponifiable matter dissolved in the anhydride while hot, but crystallized out on cooling. The hot solution was poured into a beaker of water and a yellowish oily mass separated. This was boiled with several portions of water, decanting the water each time, until the latter was no longer acid to litmus. The residue was then dissolved in hot alcohol, from which, on cooling, white clusters of fine crystals separated. Their melting point was then determined by the mercury method. One or two crystals were placed on the clean surface of mercury contained in a nickel dish and covered with a clean glass such as is used on microscope slides. The bulb of a thermometer was completely immersed in the mercury and the latter slowly heated with a micro-burner. The crystals were observed through a large lens and the temperature at which they began to melt was noted and taken as the melting point. The temperature at which the crystals completely melted is also given in the following table, being generally 1° or 2° higher.

(a) PER CENT.

0.943	0.924	0.942	0.943
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(b) MELTING POINT, DEGREES CENTIGRADE.

128	105	103	102
(130)	(106)	(105)	(104)

11. LIEBERMANN-STORCH TEST.

The test was carried out in exact accordance with the directions given in Bulletin 109 of the Department of Agriculture, Bureau of Chemistry. None of the samples gave the fugitive violet color characteristic of rosin or rosin oil. Each, however, gave a permanent coloration varying from greenish black to reddish green. The test gave negative results in each case.

12. REFRACTIVE INDEX AT 25° C.

The refractive index was determined with a Zeiss Abbé refractometer at 25° C. on portions of the freshly filtered oil. In each case readings were taken on more than one portion of each sample. These readings are as follows:

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
1.4798	1.4796		1.4801
1.4798	1.4796	1.4800	1.4799
1.4798	1.4794	1.4800	1.4802
1.4802	1.4794	1.4799	1.4800
<hr/>	<hr/>	<hr/>	<hr/>
1.4799	1.4795	1.4800	1.4800

13. ACETYL VALUE.

The Benedikt-Lewkowitsch method as described in Bulletin 107, revised page 142, was followed. Twenty-five c. c. of the filtered oil were boiled in a beaker with an equal volume of acetic anhydride for 2 hours. It was found necessary to add more anhydride from time to time to replace the loss by boiling. This mixture was then poured into a large beaker containing 500 c. c. of water and boiled 30 minutes, with a small stream of CO₂ passing into the water near the bottom to prevent bumping. The water was siphoned off, fresh water added, and the process repeated several times until the water was no longer acid to litmus. The acetylated oil was separated as completely as possible from the water in a small separatory funnel and filtered hot through a dry filter in a steam-jacketed funnel. It was then dried at 105° C. for about an hour.

About 3 or 4 grams of the acetylated oil were weighed from a dropping bottle into a 300-c. c. Erlenmeyer flask, and to this were added 50 c. c. of N/2 alcoholic KOH, the exact equivalent of which in terms of N/2 H₂SO₄ was later determined by titration. This was saponified for one hour under a reflux condenser. The alcohol was next evaporated off completely and the soap dissolved in water. To this solution was added the amount of N/2 H₂SO₄ equivalent to the alcoholic KOH previously added, and the flask was warmed on the steam bath until the two layers had separated. The contents were filtered hot through a wet filter and the oil was washed with boiling water until the filtrate was no longer acid to litmus. Finally, the filtrate was titrated with M/10 KOH and phenolphthalein. The acetyl value is the number of milligrams of KOH required in this process by 1 gram of the acetylated oil. The results obtained follow:

40.6	47.6	51.9	54.0
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Although the directions in Bulletin 107 read: "Boil the oil or fat with an equal volume of acetic anhydride for two hours," it seemed to us that if this were done in an open beaker or flask there would be con-

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siderable danger of oxidation. This oxidation would probably mean the formation of new hydroxyl groups in the oil molecules, and these in turn would exchange their hydrogen for an acetyl group, with the result that the acetyl value found would be too high. Moreover, we find that Benedikt and Lewkowitsch* direct that for the determination of the acetyl value of *fatty acids*, boil with an equal volume of acetic anhydride for two hours "in a round-bottomed flask attached to an inverted condenser." Accordingly, we repeated the previous experiment, boiling the oil and the anhydride for two hours under a reflux condenser. The rest of the analysis was carried out exactly as above described with the acetylated oil. The results obtained, which are given below, were only about half those previously obtained and would seem to show that it is not safe to acetylate the oil except under a reflux condenser. It is believed that the following values are the correct acetyl values of the samples, and we omit those first found from the final summary of this report:

21.4 27.8 25.0 30.5

14. HEXABROMIDE TEST.

Tolman's method as described in the circular of the Committee was followed as closely as possible. The results, however, were very unsatisfactory. The weighing bottles used were only about 4 ins. high and consequently permitted the addition of only about 20 c. c. of absolute ether. Otherwise, the analysis was carried out as the circular directed. Three series of tests (A, B, and C) were made, with the following results:

Sample No.	Series A.		Series B.		Series C.	
	Hexa-bromide, per cent.	Melting Point of Hexa-bromide, in °C.	Hexa-bromide, per cent.	Melting Point of Hexa-bromide, in °C.	Hexa-bromide, per cent.	Melting Point of Hexa-bromide, in °C.
1	35.1	118	58.32	118.5	47.23	118
2	30.4	119	52.66	119	41.31	121
3	31.5	119	52.77	119	44.15	120
4	28.9	119	58.93	119	42.88	120

The discrepancies in the results are so very large that we omit this test from the general summary of our report.

15. IODINE NUMBER.

Hanus Method.—The directions given in Bulletin 107, page 136, were followed. The thiosulphate solution was standardized with the sample of pure $K_2Cr_2O_7$ furnished by the Committee. About 0.2 to

* Chemical Analysis of Oils, Fats and Waxes, 1895 edition, page 128.

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0.25 gram of the freshly filtered oil was weighed from a dropping bottle into a wide-mouthed 16-oz. bottle provided with a ground glass stopper. To this were added 10 c. c. of pure chloroform and then 25 c. c. of the Hanus solution from a pipette. The bottle was stoppered and allowed to stand, with occasional shaking, for 30 minutes. Fifteen c. c. of 10 per cent. KI solution were then added; after shaking, 100 c. c. of water were added and the iodine was titrated with the N/10 thiosulphate solution. Care was taken to keep the temperature as nearly constant as possible during the analysis and two blanks were run with each set of analyses. The results follow:

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
187.7	184.8	187.3	190.6
187.7	186.3	189.0	188.1
<hr/> 187.7	<hr/> 185.6	<hr/> 188.2	<hr/> 189.3

Wijs Method.—The iodine number was also determined by means of the Wijs solution, in order to compare the results obtained by the two methods. This is the method in use in this laboratory for the determination of iodine numbers.

The Wijs solution was made up by dissolving 13.2 grams of iodine in glacial acetic acid (99.5 per cent.), and then passing chlorine gas into the solution in sufficient quantity to double the halogen content. The point at which this takes place is shown by a change in color of the solution from a dark brown to a considerably lighter brownish red.

About 0.2 to 0.25 gram of the oil was weighed out into the same kind of a bottle as previously described, and to it were added 10 c. c. of chloroform and 25 c. c. of Wijs solution from a pipette. After standing tightly stoppered for one hour, 40 c. c. of a 10 per cent. KI solution were added and the iodine was titrated with the same N/10 thiosulphate solution as was used in the Hanus method. Two blanks were run and the same precautions against change in temperature were observed. The results are given below:

189.2	185.1	188.8	187.4
189.8	184.0	189.3	186.8
<hr/> 189.5	<hr/> 184.6	<hr/> 189.1	<hr/> 187.1

ADDITIONAL ANALYSES.

The specifications adopted by the Treasury Department in Washington in 1907* state with regard to linseed oil, that it "shall conform to the following physical and chemical tests: Specific gravity at 15.5° C., not less than 0.933; flash point (open cup), not less than 280° C.;

* See Holley and Ladd: Mixed Paints, Color Pigments and Varnishes, 1908 edition, page 66.

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viscosity at 20° C., as determined by the Engler viscosimeter (water being 100), not less than 750; iodine absorption number as determined by Wijs' method (time of absorption two hours), not less than 175; to be entirely free from all acids except fatty acids, of which not more than 2 per cent. calculated as linolic acid should be present;* when heated to 300° C. and allowed to cool, the oil should show no suspended matter or deposit, and must show excellent drying qualities, as demonstrated by the Livache method."

The only tests in these specifications which are not included among those prescribed by the Committee in their circular, are the viscosity and flash tests. It seemed advisable, therefore, to make these tests upon the samples submitted, and we here include the results obtained.

VISCOSITY.

The determination of the viscosity was carried out in a Saybolt Universal Viscosimeter instead of the Engler, which was not available. The jacket bath of the instrument was brought to 20° C. and the well-shaken but unfiltered sample of the oil was also brought to this temperature. The oil was run through the instrument several times, until it no longer contained any bubbles and until two successive determinations did not vary by more than 3 seconds in the time required to fill the 60-c. c. graduated glass flask.

After the four samples of oil had been run, the viscosimeter was thoroughly cleaned and the viscosity of the water determined at 20° C. This was found to be 28, i. e., 60 c. c. of water ran through the orifice in 28 seconds. The results are given as follows:

VISCOSITY AT 20° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
3m. 42s.	3m. 50s.	3m. 20s.	3m. 45s.
3 45	3 50	3 22	3 45
<hr/>	<hr/>	<hr/>	<hr/>
224 S.	230 S.	201 S.	225 S.

FLASH POINT.

The flash point was determined by the open cup test. A Fahrenheit thermometer was suspended in the oil and the oil in the cup slowly heated. The temperature at which the first distinct puff of blue flame shot across the surface of the oil when a very small lighted jet was swept across it was taken as the flash point. The results are also calculated to Centigrade readings. The oil was not filtered.

575° F.	560° F.	580° F.	583° F.
302° C.	293° C.	304° C.	306° C.

* This corresponds to an acid number 4.5.

In the summary of this report, the results of Test 4a—loss at 105° C. in CO₂, and Test 14—Hexabromide Test, are omitted, as the results are unsatisfactory and are not, in our opinion, reliable. In cases where duplicate or triplicate analyses were made, the average figure has been taken.

REPORT OF A. P. BJERREGAARD.

Agricultural Experiment Station, New Mexico.

This work was done by the methods suggested in the printed circular received, except as herein stated. The specific gravity was determined in a 50-c. c. pyknometer with a thermometer in the stopper.

1a. SPECIFIC GRAVITY AT 15.5° C.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.9348	0.9325	0.9330	0.9340

1b. SPECIFIC GRAVITY AT 25° C.

0.9296	0.9331	0.9285	0.9294
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

0.50	0.20	0.30	0.50
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3. BREAKING TEST.

The breaking test was made by heating 15 to 20 c. c. of the oil to 300° C. in test tubes immersed in an oil bath, and maintaining that temperature for one hour. The results follow:

Breaks.	Does not break.	Does not break.	Breaks.
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This method was employed to make an observation on the amount of thickening produced by this treatment, and the color of the thickened product. This is a very important test from the varnish makers' point of view.

Samples Nos. 1 and 4 became very heavy in body, as heavy as a standard sample known to be used by a large varnish firm; No. 2 was much thinner, and No. 3 still thinner. After cooling, a penetration test on porous paper was made, No. 2 penetrating a little better than any of the others.

All the samples showed a strong green fluorescence; No. 2 was darkest in color, No. 3 was next, and Nos. 1 and 4 were palest, while No. 4 was greener in tint than No. 1. When viewed across the thickness in the test tube, Nos. 1, 3, and 4 were paler than when raw, while No. 2 was practically the same color as when raw.

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4. MOISTURE AND VOLATILE MATTER.

The determination of the moisture and volatile matter was made in two ways. First, about 4 grams of the oil were weighed into 200-c. c. Erlenmeyer flasks provided with rubber stoppers carrying the necessary glass tubes; all the flasks were then arranged in one train, immersed in a calcium chloride solution, dry hydrogen passed through, and when all the air was displaced, the oil was heated to 110° C. while the hydrogen stream was continued for 3 hours. Care was taken to permit the glass to reach moisture equilibrium in the balance case by letting it stand therein overnight before weighing. A gain in weight was observed with Nos. 1, 2, and 4, and a slight loss with No. 3. It was thought that this gain might have resulted from traces of air entering the apparatus while adding acid to the zinc in the evolution flask, and thereby causing oxidation of the oil. Later results in drying oil on litharge do not sustain this view, because there was no gain in weight of the oil and litharge in 5 hours.

Another series of moisture determinations was then tried, this time in open dishes placed in the water-jacketed hydrogen oven. Both porcelain and platinum dishes were used, but no difference can be seen in the results. The oven was filled with dry hydrogen free from air before beginning to heat it, and care was taken to pass a rapid stream of the same dry hydrogen throughout the 5-hour drying period, and the whole night while the apparatus was cooling down. Here also a gain in weight is observed with Nos. 1 and 4 and one of the duplicates of No. 2, and a loss in weight with No. 3 and the other duplicate of No. 2.

The gains are much smaller in this series, however. A plausible explanation of these gains appears to be that hydrogen gas is soluble in and is absorbed by the oil. To test this hypothesis, experiments were started to dry the oil in an atmosphere of dry Co_2 , but they were spoiled by an accident, and lack of more unfiltered oil prevented a repetition.

The oils in the flasks from the first drying experiment were heated with free access of air in an oven to 110° for $2\frac{1}{2}$ hours. Very substantial gains in weight were obtained.

The results of this test are as follows:

(a) PERCENTAGE OF MOISTURE AND VOLATILE MATTER IN HYDROGEN.

(Allowing to stand over night before weighing.)

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
0.10 gain	0.13 gain	0.08	0.08 gain

(b) DRYING IN HYDROGEN OVEN.

0.05 gain	0.00	0.18	0.01 gain
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5. PERCENTAGE OF ASH.

0.156	0.047	0.048	0.159
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6. DRYING TEST ON GLASS IN DAYS.

Archbutt's drying test on glass was carried out as directed. On account of the impossibility of placing the glass slips absolutely horizontal, the oil became irregularly distributed on them. The results recorded are for the thicker places on the glass. At the same time a series of drying tests on glass by the ordinary factory method was carried out. That is to say, the oil was spread over the glass, which was then set nearly vertical, so that the excess of oil could drain away. All of the oils dried more quickly by this method than by Archbutt's. The results, giving the time in days, are as follows:

(a) Glass Horizontal.

Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.
Over 7	Over 6	Over 6	Over 7
	4	6	7

(b) Glass Vertical.

4	3	3½	4
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7. OXYGEN ABSORPTION.

In the test of the oxygen absorption on lead oxide, ordinary flake litharge was used instead of the sample sent, because the latter was not in sufficient quantity. Tin dishes 2½ ins. wide and ¾ in. deep (tops of preserve glasses), were used because we had no aluminum trays. No suitable place free from dust and exposed to light was available, so these trays were kept in a rather tight drawer during the test, and therefore in the dark. A very great difference in the rate of drying was found between oil on 5 and on 10 grams of the litharge. The gains in weight have been calculated to percentage of the original weight of oil and tabulated. The results are given in the accompanying Tables I and II.

(a) 5 grams litharge.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
6.28	540	5.11	540	6.74	540	6.86	540

(b) 10 grams litharge.

15.04	277	11.53	540	14.64	277	15.17	277
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8. ACID NUMBER.

1.21	3.49	1.91	1.57
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9. SAPONIFICATION NUMBER.

184.5	183.7	183.7	185.5
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TABLE I.—DRYING OF OILS ON LITHARGE, SAMPLES 1 AND 2.
Per cent. gain in weight of oil.

Time in Hours.	Sample No. 1.			Sample No. 2.			
	Weight of PbO used, grams.			Weight of PbO used, grams.			
	5.	5.	10.	5.	5.	10.	10.
24	0.44	0.65	0.66	1.75	1.99	7.53	7.81
32	1.31	1.65	4.08	3.26	3.62	8.00	8.35
48	3.08	3.42	9.84	3.71	4.06	8.54	8.83
55	3.60	3.92	11.03	3.80	4.19	8.82	9.12
84	4.37	4.62	12.53	3.87	4.29	8.97	9.28
108	4.88	5.15	13.80	4.07	4.52	9.42	9.63
115	4.91	5.18	13.96	4.08	4.56	9.46	9.66
132	4.97	5.28	14.37	4.14	4.63	9.67	9.88
180	5.06	5.39	14.70	4.30	4.87	10.06	10.18
204	5.06	5.41	14.78	4.35	4.92	10.25	10.40
228	5.06	5.48	14.89	4.44	5.01	10.44	10.55
252	5.10	5.52	14.95	4.53	....	10.53	10.68
277	5.10	6.06	15.04	4.59	....	10.73	10.84
302	5.17	6.08	15.01*	4.61	....	10.80	10.90
348	5.17	6.08	14.99*	4.64	....	10.93	11.00
396	5.24	6.16	15.02	4.84	....	11.13	11.22
444	5.27	6.21	14.97*	4.92	....	11.24	11.30
540	5.26*	6.28	14.97	5.11	....	11.46	11.53

TABLE II.—DRYING OF OILS ON LITHARGE, SAMPLES 3 AND 4.
Per cent. gain in weight of oil.

Time in Hours.	Sample No. 3.				Sample No. 4.			
	Weight of PbO used, grams.				Weight of PbO used, grams.			
	5.	5.	10.	10.	5.	5.	10.	10.
24	1.84	1.52	6.19	5.18	1.57	1.36	4.35	4.92
32	3.09	2.75	9.54	8.39	2.75	2.60	7.11	8.56
48	4.63	3.90	10.18	10.08	4.27	4.44	10.13	11.97
55	5.16	4.15	10.79	11.61	4.62	4.91	....	12.74
84	5.53	4.22	13.54	12.13	5.01	5.52	11.52	13.47
108	5.94	4.47	14.14	12.59	5.42	5.99	12.18	14.31
115	5.99	4.63	14.20	12.67	5.42	6.00	12.13*	14.43
132	6.07	4.67	14.31	12.89	5.48	6.08	12.34	14.76
180	6.20	4.80	14.39	13.13	5.51	6.17	12.60	15.00
204	6.25	4.84	14.47	13.31	5.58	6.25	12.73	15.09
228	6.31	4.93	14.56	13.45	5.62	6.30	12.87	15.10
252	6.35	4.99	14.57	13.49	5.67	6.37	12.95	15.10
277	6.39	5.06	14.64	13.65	5.75	6.43	13.08	15.17
302	6.45	5.11	14.60	13.61*	5.75	6.47	13.12	15.12*
348	6.49	5.17	14.54*	13.61	5.79	5.53	13.17	15.04*
396	6.58	5.20	14.54*	13.73	5.87	6.64	13.14*	15.02*
444	6.63	5.38	14.50*	13.73	5.89	6.71	13.17	14.90*
540	6.74	5.56	14.44*	13.73	6.00	6.86	13.29	14.81*

* Loss of weight.

10. UNSAPONIFIABLE MATTER.

In the determination of unsaponifiable matter, it was found that 100 grams were far too large a quantity to handle conveniently. In the absence of a 2000-c. c. separatory bulb, the soap solution was divided into two equal parts, and a 1000-c. c. separatory used. After six extractions the well-washed sixth ethereal extract still contained large quantities of matter in solution. Lack of time has prevented further work with smaller quantities of the oils.

The remaining tests were not made, due either to lack of instruments or of time.

APPENDIX II.

REPORT OF JOINT SUB-COMMITTEE OF COMMITTEES E AND U ON INVESTIGATION OF THE INHIBITIVE POWER OF CERTAIN PIGMENTS ON THE CORROSION OF IRON AND STEEL.

The Sub-Committee appointed from Committees E and U held two meetings during the year. It was determined to purchase in the open market fifty different pigments representing material in ordinary use. Small samples of these pigments were distributed among various chemists for testing, according to the method suggested by Mr. G. W. Thompson, as described by Mr. A. S. Cushman in the Proceedings of the last Annual Meeting, Vol. VIII, pp. 605-610. These tests consisted of putting carefully weighed samples of different kinds of steel into bottles connected together in the same manner as a train of wash-bottles, equal quantities of the different pigments to be tested being inserted in the successive bottles, together with an equal volume of water. Air was then bubbled in for various lengths of time, after which the samples of steel were removed, cleaned with a brush, dried, and re-weighed. The condition of the surface and the loss in weight were noted. These tests were made independently and simultaneously by five different chemists, and the results were plotted and compared. From these comparisons the pigments were divided by your Committee into three classes, which were tentatively called "inhibitors, indeterminates, and stimulators." From these, ten inhibitors and nine stimulators were selected, but this selection was made only when the five experimenters were unanimous in finding that the substances had fallen into these respective classes. In all cases in which there was lack of agreement among the experimenters, the pigments were eliminated from further consideration.

To determine the value of these laboratory tests, the Paint Manufacturers' Association agreed to erect on a piece of land

leased by them at Chelsea, a suburb of Atlantic City, a number of steel plates for making practical service tests. The paints used were single pigments from the inhibitor, indeterminate, and stimulator classes, also composite pigments and variations in pigments used in the several coats so as to obtain a theoretical inhibitor under coat and an excluding final coat, all ground in the same vehicle. The steel plates were rolled from Bessemer steel, basic open-hearth steel, and a special pure iron.

The exposure of these panels has been too short to give positive indications of the value of these tests, and it would be premature to make any statements at this time. In the opinion of the Committee, however, the results of these tests will be of great practical value, owing to the care with which uniformity of conditions has been maintained and recorded. The Committee wishes to express its high appreciation of the assistance rendered by the Paint Manufacturers' Association and the steel manufacturers, which has made these tests possible.

Respectfully submitted on behalf of the Joint Committee,

S. S. VOORHEES,
Chairman pro tem.

DISCUSSION.

MR. H. E. SMITH.—With regard to the report of the Committee on Linseed Oil, the values of the specific gravity are given at 15.5°C ., which has the support of long practice; but 20° or 25°C . would really be more convenient. Mr. Smith.

MR. G. W. THOMPSON.—Tests were made both at 15.5° and 25°C . The Committee felt it would not be safe to condemn 15.5° and establish 25° ; so they used both. It is easier to make a determination at 25° than at 15.5° , as is borne out by the fact that there is a better agreement between analysts at 25° than there is at 15.5° . Mr. Thompson.

MR. G. D. WHITE.—I would like to ask Committee E one question: I recently examined the Havre de Grace bridge, and it would appear from a superficial examination that the paint on the bridge is wearing better than that on the test plates. I was wondering whether the Committee has come to that same conclusion; and if so, whether they have any reason to advance for that condition. Mr. White.

MR. S. S. VOORHEES.—We found that was true in one or two cases, but the difficulty of making a thorough inspection of all parts of the bridge is such that we were not justified in making a statement as to the bridge itself. We feel that the paints, as a rule, are in good condition. They need, however, a longer time to give any positive data and we hope, as stated, that photographs will be made of all of the panels and perhaps of some sections of the bridge, and that one of the steel plates in each set exposed will have the paint removed in order that photographs may be made of the metal underneath. Mr. Voorhees.

MR. C. D. RINALD.—I have not examined the bridge, but I have been told by a practical painter that the balance of it appears to be in better condition than the panels on which the tests have been made. This is disappointing news because when those panels were started I felt rather sanguine about the Society's chances of getting tangible results regarding the behavior of the different paints when used on a large scale. For twenty years or Mr. Rinald.

Mr. Rinald.

more I have carried on laboratory tests with all the more prominent paints in the market, in an endeavor to arrive at reliable conclusions for my own use. The results are such that I am less positive now of my knowledge than I was before starting them. It is a curious fact, supported by the experience of others as well as myself, that laboratory experiments, no matter how carefully made, do not give the same results as obtained in actual use. I had hoped that in this case, where the conditions for forming reliable conclusions were so nearly ideal, the field tests and laboratory tests would show a better agreement, but it seems to me now that such will not be the case.

In that connection I would like to say with regard to the tests that I have been making right along in a small way, that every now and then instances came up where purchasers wanted a guarantee that a certain grade of paint would stand certain exposure. We always refuse to give such guarantees even though we feel justified in telling them, "Go ahead, probably it will stand it." I would then start in and conduct exposure tests and continue them for two or three years. I remember some which did not come out very satisfactorily, so that I went to the special bridge or building in fear and trembling, afraid that the paint must have perished. I found, on the contrary, that it had stood much better than my experiments had indicated. This has happened repeatedly and not knowing how to account for it, I should welcome an explanation. It seems to me that when you use paint on a large scale it forms a homogeneous mass, and thus where you have everything covered with the same kind of paint it will often last much longer than where you have it on small surfaces only.

Mr. Thompson.

MR. THOMPSON.—I think it would be unfortunate for the statement of Mr. White to be uncontested. I am not willing to admit what Mr. White has said. I have seen those plates a good deal and have seen the bridge a good deal, and I am not willing to admit that the plates are not showing as good results as the bridge. It must be remembered that the plates are in some respects more exposed than the bridge; but so far as you can see the paints are doing good work on the plates at the present time. There is not one of them which has not given good protection. I am not speaking for the Committee, but simply as an individual as to what I have seen. I can simply put my opinion at this time against

Mr. White's. I will explain what may, perhaps, not be understood, that there were nine test plates painted for each paint. These were placed right alongside of the corresponding panels of the bridge. Now I want to ask Mr. White if he refers to the rest of the bridge, or to that part of the bridge opposite the panels? Mr. Thompson.

MR. WHITE.—I referred to the part of the bridge opposite the panels. Mr. White.

MR. THOMPSON.—The rest of the bridge was not painted under the jurisdiction of the Committee at all. There were nine panels painted, using each paint; three of them spread at 1,200, three at 900, and three at 600 sq. ft. to the gallon. I think the report of our Committee will show that those painted 1,200 sq. ft. will not stand as well as those painted 600 sq. ft. It is possible, as Mr. White says, that the paint on the bridge may have been spread nearer 300 sq. ft. We are unable to calculate properly the spreading rate on the bridge, because the paint on the edges of a member may be $\frac{1}{8}$ in. thick on account of the running and the impossibility of spreading it smoothly. Mr. Thompson.

MR. VOORHEES.—In regard to the statement that the paint on some of the panels was possibly not standing as well as the same paint on the bridge proper, I may state this as an individual opinion, as in one or two cases I had reason to believe that the film on the panel was more brittle than that on the bridge proper; but in comparisons of this sort you are assuming that conditions are uniform, and it would not be fair to make a positive statement on an individual panel. At certain points it might be true; but that it would hold all over the panel or all over the bridge, has not been established. Mr. Voorhees.

MR. RINALD.—There are a good many independent tests going on. There is a gentleman here, I do not know that I am at liberty to mention his name, who showed me a series of tests which are extremely interesting. He had a very large number of samples in each test, only small pieces of iron, but in each case he had scratched the piece before the paint was quite dry with a wire nail diagonally across the corner but not all the way across, just leaving a little ridge at the corners. It was very interesting, indeed, to see how in some cases the rust worked its way under the paint, lifting it off; while in others the paint seemed to act Mr. Rinald.

Mr. Rinald. as an inhibitor so that there was scarcely any rusting, even on the bare metal.

Mr. Gardner. **MR. H. A. GARDNER.**—I think Dr. Walker, of the Massachusetts Institute of Technology, has brought forth a very interesting point in this matter. He has shown that when the surface of linseed oil applied to a steel plate becomes abraided, corrosion of the steel is stimulated. The hydrogen which is formed during the corrosion is rapidly removed by the linseed oil coating, which is an unsaturated compound, and this removal of hydrogen allows free corrosion to proceed. When a plate painted with red lead is scratched to the steel no corrosion seems evident, because red lead is an inhibitive pigment; whereas if the plate is painted with stimulative compounds scratching causes corrosion. To develop this fact the Paint Manufacturers' Association, acting under the advice of Committee E, have placed a scratch on the upper right hand corner of all the plates painted on the steel test fences at Ventnor, N. J. Three months later an inspection will be made to learn the condition of the various steel plates as affected by this test.

Mr. Evans. **MR. S. M. EVANS.**—We hear again those familiar words, "stimulators and inhibitors." I remember last year we had considerable discussion on this subject, with some reference to the possible insulating effect of the linseed oil film in these so-called stimulative paints. I should like to know if anybody can throw any further light on that aspect of the question. Have any results been obtained corroborative or otherwise of the theory that the linseed oil film itself acts as an insulating agent?

Mr. Gardner. **MR. GARDNER.**—It does for a certain length of time. However, as soon as the linseed oil coating is subjected to sufficient exposure it will break down and galvanic currents will be set up causing active corrosion to proceed. To prove this point I attached a copper plate to either end of a paint film made of stimulative carbon pigments, and to the end of the copper plates I attached wires running to a battery, and placed a galvanometer in the circuit. There was no passage of current through the paint film, the linseed oil acting as a non-conductor. The paint film was then subjected to a treatment with water, and after the film had soaked up considerable water it was again placed in the circuit. Deflections of the galvanometer showed that a passage of current

was taking place. This seems to show that corrosion of steel **Mr. Gardner.** painted with pigments which are good conductors of electricity is imminent. This experiment also shows that as long as the linseed oil coating remains dry and intact no current will pass through; but as soon as it takes up enough moisture and becomes disintegrated, the current passes and corrosion proceeds.

MR. EVANS.—That would seem to be a very good test for the **Mr. Evans.** classification of pigments as suggested by Mr. Voorhees.

MR. GARDNER.—I think so, but we have not yet worked it **Mr. Gardner.** out fully.

MR. P. FIREMAN.—I would like to say a few words with regard **Mr. Fireman.** to the joint report of Committees E and U. I can hardly admit that the experiments carried out have been rationally arranged, and that the results are of a nature that can be easily assimilated. Mr. Cushman especially taught us that soluble material in paint is its greatest enemy, the cause of corrosion, and all that sort of thing. Now he himself goes ahead and takes up a whole lot of pigments pell-mell; we know nothing about them, whether they contain soluble material or not, and what can be expected under such conditions but that the results will be more or less indefinite? Are the injurious effects due to the pigments, or due to the impurities? To my mind the entire series of tests, although carried out by a number of investigators, are futile; and the conclusions are also very peculiar, to say the least. We learn that there are certain inhibitors. What are they? When a chemist hears something about chromates he immediately recalls that the chromates are oxidizing agents, and he thinks there must be something in that. He begins to think that the chromates may have some virtue. Now zinc oxide is fully as good an inhibitor as the chromates; and yet it has no oxidizing properties, nor any reducing properties either. In making tests of the kind described, each pigment should be first analyzed and tested for purity; then perhaps we will be able to talk about results, and what they mean. It would have been much better to have taken half a dozen pigments and thoroughly studied them, and to have made tests with them under various conditions, than to take forty or fifty pell-mell, and get results that to my mind are meaningless and misleading.

The President.

THE PRESIDENT.—I do not hold any brief for the Committee, and although I am a member of the Committee I did not make any of the tests that are published. I would like to say two things: first, that as opening up a new subject, one absolutely new to all of us, I think, the Committee deserves very great credit. The fact that pigment has an influence on the rate of corrosion of metal is really a stupendous fact to me; and while I might be willing to agree with the last speaker that some of the details of the test, and some of the methods, could be better, I cannot forget the fact that a lot of pigments selected in the market which are being used from day to day, which I understand was the reason why they were taken in this test, do show a very wide difference in their effect on corrosion when treated alike. That fact to me is one of tremendous importance. I do not understand that the Committee regards these tests as final, and I for one am extremely willing to give the Committee every credit and especially Mr. Thompson who originally suggested the experiments.

The second point I wish to speak of is that as a consumer I am in rather a difficult position. Soon after these tests were published I asked for a copy to be sent me, and, being a member of the Committee, it was deemed legitimate that I have a copy. I went over the data very carefully, and our people said to me: "What shall we do? You have been recommending now for a number of years that we should coat our steel with lampblack paints. Here these tests indicate that lampblack is a stimulator of corrosion; now what are you going to do about it?" So you see I have been in rather a tight position. I do not think the Committee feels they have got the final truth yet; hardly a month passes that some new developments do not come up. We are in a period of tremendous transition. So I have said to our people: "Let us hold on to what we have got till we have a little more data under our feet; then we will tell you what we think ought to be done."

Mr. Walker.

MR. P. H. WALKER.—There is one serious objection to the idea that all these pigments before they were tested should have been accurately analyzed; it may be a bad thing for a chemist to get up here and say so, but it cannot be done. The materials that influence corrosion may be present in exceedingly minute quantities. Some of these pigments are made with organic acids;

the chromates themselves, for instance, may contain a small amount of organic salts. A chemist cannot certainly determine that. His errors of analysis will be greater than the impurities affecting corrosion; whereas in performing these experiments on the steel according to Mr. Thompson's plan, we get certain values. The Committee has gone ahead and made practical paint tests without reference to any theory in regard to inhibitors and stimulators. Mr. Walker.

Certain pigments apparently of the same composition may, in reality, behave differently. We had such an experience with two Prussian blues, which gave different results in the tests. I believe one of these blues contained a trace of chromium, and the other did not.

MR. GARDNER.—We scoured the market for the best materials obtainable. In nearly every case I made analyses of the pigment to determine the percentage of soluble matter they contained. In one or two cases very slight traces of acid were found. Mr. Gardner.

It has just been asked why zinc oxide should be regarded as an inhibitor. I think very likely that the inhibitive nature of this pigment is due to the fact that it is soluble to a very slight extent, and being by nature a base, it may assert the inhibitive nature that is common to most bases which in water develop large quantities of hydroxyl ions. We have two soluble materials on the test fence. One is zinc chromate, and this is a very good inhibitor; the other is calcium sulphate, and this is a very active stimulator. Both these materials are soluble to a certain extent in water. The reason that the calcium sulphate stimulates corrosion may be due to the ionization of its sulphuric acid content. Calcium sulphate ionizes very readily in the presence of moisture and evidently stimulates corrosion to a great extent. In fact all the steel plates on the test fence which were painted with calcium sulphate, have become brown all over from the rust that is taking place. The reason no corrosion seems evident on the plates painted with black pigments may be due to the fact that black is very deceptive and the inspector cannot see through to the surface; but I think that if the film of paint was to be removed, corrosion would be seen underneath on the plate in some cases.

MR. THOMPSON.—If these tests taken alone condemn any particular pigment they are, to my mind, unwise tests. I mean Mr. Thompson.

Mr. Thompson. by that merely that the value of the tests will be determined by the painting tests. Now it may readily be found later that a certain pigment in small amount may be stimulative, and that in larger amount it may be in an entirely different class. The object of these painting tests is to determine whether the test which I suggested originally agrees with the exposure tests; in other words, whether a pigment which shows itself to be an accelerator of corrosion in water, will show itself to be an accelerator of corrosion in linseed oil. If the results of the tests in linseed oil do not correspond with the tests in water, then the test falls down. There is no question about that. No conclusions should be drawn now. We may start off with an hypothesis, but it is only a working hypothesis to lead us on to new fields.

Mr. Voorhees. **MR. VOORHEES.**—I believe that we are going too fast in the use of the terms “accelerators and inhibitors.” The test was made under purely laboratory conditions, and the connection between the results obtained with the pigment in water suspension and when applied as an oil film has not been entirely established. The exposure tests that we have under consideration are being carried on so as to connect theory with practice. One aim of the Committee has been to develop accelerated tests which would be in harmony with service; for unless accelerated tests are in harmony with service tests they have no value. I think that we must fully establish the fact that a pigment which has a corroding action on metal when suspended in water has a similar action when it is applied in an oil film as a paint. This is one of the problems which we hope the Committee will investigate during the year.

Mr. Lane. **MR. F. A. LANE.**—Two years ago I started a number of tests on steel plates. It was just before this agitation concerning accelerators and inhibitors. You may be interested to learn that two of the accelerators that have been shown to act in conjunction with one another in equal parts, in a vehicle composed of 90 per cent. of linseed oil and other materials, showed the best results in withstanding oxidation. We have had no indication of corrosion for two years and three months; therefore, it goes to show that a pigment may be an accelerator in water, but in a proper vehicle it may be the direct opposite. I refer to a lead compound and lampblack, giving a bluish-black coating, exceedingly dense in

color, with a thin film, covering 1,000 sq. ft. per gallon under **Mr. Lane.** repeated tests on very large surfaces.

MR. GARDNER.—I do not think that these experiments have **Mr. Gardner.** proceeded to such an extent that they are of much value as yet. Lampblack in oil forms a fairly good excluding coat. This excluding action is good for sometimes three years, and no corrosion may take place during that time; but finally, when the paint film breaks down, corrosion proceeds to a greater extent than before. Black pigments are often good excluders but not good inhibitors. I think it will be two years before Mr. Lane will get practical results from his experiments.

MR. R. S. PERRY.—Mr. Walker referred to two blues, one **Mr. Perry.** of which was a stimulator and the other an inhibitor; yet chemical analyses failed to find any difference between them. I made those two blues, and they were made purposely to determine whether they would support Mr. Thompson's work. Those two blues that were subjected to Mr. Thompson's test analyzed exactly alike. The one was purposely made in the presence of a soluble rust stimulative; the other was purposely made in the absence of anything known as a rust stimulative. A chemist cannot detect by any difference in the analyses of those two blues the conditions under which they were made, but in their effect on iron they exactly support, in a practical field test, the past results of the laboratory work of Mr. Thompson.

REPORT OF COMMITTEE D-I ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

The investigations on preservative coatings have broadened to such an extent as to require a re-organization of the Committee with a very material enlargement of the membership. It was necessary to define the lines of investigation and state clearly the results which it was hoped to accomplish. To this end the following rules and statement of policy of Committee D-I were adopted:

RULES OF COMMITTEE D-I.

1. The Officers of Committee D-I shall be a Chairman, a Vice-Chairman, and a Secretary, to be elected annually.

2. Members may be added to Committee D-I, at any time, by appointment by the Advisory Committee after approval by the Executive Committee of the Society.

3. The following standing sub-committees and their chairmen shall be appointed by the Chairman of Committee D-I, abolishing all old sub-committees:

- (a) Advisory committee of six to act with the Chairman, Vice-Chairman, and Secretary, for the Committee between meetings.
- (b) On inspection of the Havre de Grace Bridge.
- (c) On inspection of the wooden panels at Atlantic City.
- (d) On the steel fence at Atlantic City, to collaborate with sub-committee of Committee A-5.
- (e) On linseed oil.
- (f) On the definition of terms used in paint specifications.
- (g) On the influence of pigments on corrosion.
- (h) On accelerated tests.
- (i) On varnish.
- (j) On testing white paints.

The chairman of each sub-committee shall be designated by the Chairman of Committee D-I.

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The Chairman of Committee D-I shall appoint such other committees as may be necessary.

4. All actions taken by Committee D-I shall be subject to review and approval by the Executive Committee of the Society.

5. Three regular meetings of Committee D-I shall be held: one at the annual meeting of the Society, one in November, and one in May of each year.

6. Absence from two consecutive regular meetings without notice to the Chairman or Secretary shall be considered as a resignation.

7. The policy of the Committee is that no reports of committee work be made public except over the Chairman's signature.

STATEMENT OF PLAN AND POLICY OF COMMITTEE D-I.

Committee D-I, on Preservative Coatings for Iron and Steel, was organized in 1902 to investigate the problem indicated by the title. The work of the Committee has broadened however during the past few years so as to cover the preservation of materials of construction in general by paint and similar coatings. To meet these conditions the Executive Committee of the Society at its last meeting extended the scope to be covered by the work of the Committee, so that it is now a "Committee on Preservative Coatings for Structural Materials." The growth and importance of the Committee's work, furthermore, have been such that the Committee has been re-organized with an Advisory Committee having executive powers, and a number of sub-committees with powers to investigate, etc., along specific lines.

It has become evident to the members of the Committee that its membership should be enlarged by adding thereto technical men of ability and experience who are interested in preservative coatings, so that the Committee would become an organization of paint chemists and experts within the American Society for Testing Materials. It is thought such a plan of organization will enable its members to confer with reasonable frequency on technical questions. These conferences, say three times a year, will be of inestimable value in aiding the work of the Committee.

In order that the work of the Committee shall develop on broad lines, and be of the greatest practical value in its field of investigation, it is most desirable that the experimenters be trained

observers who appreciate the need of accurate observations and accurate methods of testing before expressing positive conclusions or recommending definite specifications. In this way the integrity and impartial position of the Committee will be maintained and all interested will be assured of just consideration. This plan does not involve any suppression of facts, but rather a clear distinction between facts and conclusions. There should be no hesitation in reporting facts and recommending definite specifications when the established facts warrant positive conclusions.

It is to be hoped that manufacturing and consuming interests will recognize the importance of the work which we are doing, and that they will see the advisability of helping in this work by having technical representation on the Committee.

It was also decided that the reports of the standing committees are hereafter to be presented by their respective chairmen, in their natural sequence.

The reports of various sub-committees are given in the appendix to this report.

Respectfully submitted on behalf of the Committee,

G. W. THOMPSON,
Secretary.

S. S. VOORHEES,
Chairman.

APPENDIX.

REPORT OF SUB-COMMITTEE B ON INSPECTION OF THE HAVRE DE GRACE BRIDGE.

PHILADELPHIA, PA., June 8, 1910.

MR. S. S. VOORHEES,
Chairman, Committee D-1, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

The recent inspection of the Havre de Grace Bridge was held on May 5, under the following program.

The examination of the panels was divided generally into three heads, viz:

- A—Chalking,
- B—Checking, Cracking, Alligating, etc.,
- C—General Surface condition,

with a marking for each, as follows:

Excellent	10 to 8
Good	8 to 6
Fair	6 to 4
Poor	4 to 2
Failure	2 to 0

As far as possible, members of the Sub-Committee were requested to pair off with such other members of Committee D-1 who were present, though not of the Sub-Committee on Inspection. Those of the Sub-Committee present were: *W. A. Aiken, Chairman, *G. W. Thompson, *M. MacNaughton, *A. P. Hume, Anderson Polk, A. H. Sabin, *Wirt Tassin. Those marked with an asterisk (*) sent in individual reports. Mr. A. H. Sabin was the only one who collaborated with any other member of the Sub-Committee; he was with the Chairman, who also was accompanied by Mr. Gibboney, of Committee D-1. Mr. Anderson Polk has failed to hand in any report, stating that he had mislaid his notebook.

The results of the inspection are given in the Table of Ratings. The individual marks were averaged from all nine panels, covering three rates of spreading.

REVIEW.

Under A (chalking) the average rating of 18 paints was 8.8, fairly excellent; of one paint 3.6, poor.

Under B (checking, etc.), the average rating of 18 paints was 9.6, nearly excellent; of one paint 3.5, poor.

Under C (general condition), the average rating of 14 paints was 9.1, fairly excellent; of two paints 7.7, quite good; of one paint 6.6, good; of one paint 5.3, very fair; of one paint 3.6, poor.

TABLE OF RATINGS.

*Paint.	Examined for	Aiken.	MacNaughton.	Tassin.	Thompson.	Hume.	Average.	Remarks.
1	A	8	8	10	6	10	8.4	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	7.55	7	6	6	6.66	6.6	Fairly good.
2	A	8	9	1†	8	9	8.5	Fairly excellent.
	B	10	6	1†	8	9	8.2	Fairly excellent.
	C	6.44	6	1†	4.33	4.66	5.3	Fair.
3	A	8	10	8.33	6	7	7.9	Very good.
	B	10	10	10	10	10	10.0	Excellent.
	C	8.33	8	7.67	6	8	7.6	Quite good.
4	A	10	6	10	6	7	7.8	Very good.
	B	10	9	10	10	10	9.8	Nearly excellent.
	C	8.13	9	10	8	9	8.8	Fairly excellent.
5	A	10	10	10	8	10	9.6	Nearly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	8.66	8	10	8	9	8.7	Fairly excellent.
6	A	10	10	10	6	9	9.0	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	9	9	10	8	9	9.0	Fairly excellent.
7	A	9	8	10	8	9	8.8	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	8.78	8	10	8	9	8.7	Fairly excellent.
8	A	10	9	10	8	9.66	9.2	Nearly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	9.55	9	10	7.33	9	9.0	Fairly excellent.
9	A	10	9	10	8	9	9.2	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	9.22	9	10	6	9	8.6	Fairly excellent.
10	A	8	9	10	6	9	8.4	Very good.
	B	9	6	10	6	9	8.0	Very good.
	C	10	9	10	8	9	9.2	Fairly excellent.
11	A	9	9	10	6	7	8.2	Very good.
	B	9	6	10	7.14	9.66	8.4	Very good.
	C	10	8	10	7.14	9	8.8	Fairly excellent.
12	A	9	10	10	8	9	9.2	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	9	10	10	8	10	9.4	Nearly excellent.
13	A	8	10	10	8	9	9.0	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	8.55	7	10	6	9	8.1	Very good.
14	A	9	9	10	8	8	8.8	Fairly excellent.
	B	10	9	10	10	10	9.8	Nearly excellent.
	C	10	8	10	6	9	8.6	Fairly excellent.
15	A	3	5	4	4	2	3.6	Poor.
	B	2.66	5	4	4	2	3.5	Poor.
	C	2.66	5	3	2.66	4.66	3.6	Poor.
16	A	9	10	10	8	8.33	9.0	Fairly excellent.
	B	10	10	10	10	10	10.0	Excellent.
	C	10	9	10	8	9	9.2	Fairly excellent.
17	A	9	10	10	8	9	9.2	Fairly excellent.
	B	10	6	9	10	9	8.8	Fairly excellent.
	C	8.11	6	8.66	8	8.66	7.9	Very good.
18	A	9	10	10	8	10	9.4	Nearly excellent.
	B	10	10	9.33	10	10	9.9	Excellent.
	C	10	8	10	8	10	9.2	Nearly excellent.
19	A	9	10	10	8	9	9.2	Fairly excellent.
	B	10	8	9.66	10	9	9.3	Fairly excellent.
	C	10	8	10	8	8	8.8	Fairly excellent.

* The compositions of these paints are given in the *Proceedings*, 1908, Vol. VIII, pp. 173 ff.

† These values were not considered in computing the average for Paint No. 2.

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The general condition of the bridge proper was, by the majority of the individual reports, considered better than similar panels, even slightly so in the case of the paint marked "poor" throughout. One fact is emphasized—that the importance of proper preparation of the receiving surface and the application of the paint cannot be too thoroughly insisted on, as demonstrating in this test that these two features are essential to provide protection, and possibly are of more importance than the quality of the preservative coating. While this expression might appear inconsistent with the fact that the plate surfaces were very specially prepared before the application of paint, it must also be realized that the preparation of the bridge structure proper was also special in a measure, as compared with ordinary conditions of practice; first, in that these surfaces had an additional preliminary shop priming coat of oil, and were much better cleaned at the time of field painting than such structures generally are; second, in that there was no absolute concordance of the spreading rate on the bridge proper with any of the rates used on the plates, the paint coat of the bridge being probably much heavier than even that obtained through the lowest square-foot rate on the panels; and third, in that the conditions of exposure during application were not identical, the plates being painted indoors and held there until dry, while the bridge proper was of course exposed to the weather at all times. There are numerous and more or less pronounced indications which impressed the Sub-Committee, both individually and generally, that important changes are on the eve of development in many of the panels; but the consensus of opinion is now that it would be unsafe to predict anything positively at this time, as the paints generally are to-day affording excellent protection.

It had been expected to have photographs made of the plates, or certain of them, at this time, both before and after the removal of the films, but it was concluded as the result of our inspection that the time has not yet arrived for such examination.

Respectfully submitted,

W. A. AIKEN,

Chairman, Inspection Committee, Havre de Grace Bridge.

REPORT OF SUB-COMMITTEE C ON INSPECTION OF THE WOODEN PANELS AT ATLANTIC CITY.

PHILADELPHIA, PA., May 23, 1910.

MR. S. S. VOORHEES,

Chairman, Committee D-1, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

In accordance with your instructions a final inspection of the wooden-panel test fence at Atlantic City was made on April 15 and 16 by the Sub-Committee, with the following in attendance: Messrs. Aiken, Heckel,

Job, Sabin, Voorhees, and P. H. Walker. It was decided by the Sub-Committee to base the inspection upon the condition of each panel as regards (1) Chalking, (2) Cracking or checking, and (3) General surface conditions, indicating the condition in each instance numerically from ten to zero by the following scale:

Excellent.....	10 to 8
Good.....	8 to 6
Fair.....	6 to 4
Poor.....	4 to 2
Failure.....	2 to 0

Relative chalking was estimated by rubbing each panel with a piece of black velvet, and observing the whitening of the latter. It is realized that this test gives only general indications, especially when applied to surfaces exposed to the direct action of rain, since at the time of an inspection some of the chalking which had resulted might have been washed away. The indications, however, upon panels similarly exposed should be fairly comparable. The extent of checking or cracking was determined by careful examination of each panel with a magnifying glass, and the general surface condition was judged by viewing each panel carefully from a distance of about six feet.

WEST EXPOSURE.

	Chalking.	Cracking or Checking.	Surface.
W 1	8	8	8
W 145.....	7	7	8
W 3	9	7	6
W 147.....	6	7	7
W 5	6	7	7
W 149.....	7	6	7
W 7	6	8	7
W 176.....	8	7	7
W 9	9	8	7
W 175.....	8	7	7
W 11	9	9	7
W 180.....	8	8	7
W 13	8	9	7
W 181.....	5	9	8
W 15	8	8	8
W 182.....	5	9	8
W 17	9	2	2
W 177.....	6	7	8
W 19	6	6	6
W 178.....	6	8	7
W 21	7	6	6

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	Chalking.	Cracking or Checking.	Surface.
W 168.....	3	9	8
W 23	7	7	6
W 170.....	10	8	8
W 25	4	8	7
W 169.....	10	8	7
W 27	6	7	7
W 172.....	10	3	5
W 29	6	4	2
W 31	7	4	6
W 33	4	6	6

EAST EXPOSURE.

W 2	8	8	8
W 146.....	8	8	8
W 4	6	8	8
W 148.....	6	6	6
W 6	8	8	7
W 150.....	8	8	8
W 8	5	9	8
W 10	9	8	8
W 12	10	9	8
W 14	8	9	9
W 16	8	8	8
W 18	10	5	5
W 20	8	8	8
W 22	6	7	8
W 24	8	6	7
W 26	7	8	8
W 28	9	7	8
W 30	8	7	8
W 32	8	7	7
W 34	6	8	8

In the foregoing Report of Inspection, the numbers correspond to the following formulas:

Number.	Ingredients.	Per cent.
W 1	Basic carbonate, white lead.....	34.0
	Zinc oxide.....	66.0
W 145.....	Basic carbonate, white lead in oil.....	75.0
	Zinc oxide.....	25.0
W 3	Basic carbonate, white lead.....	50.0
	Zinc oxide.....	50.0

110 REPORT OF COMMITTEE D-1 (Proc., Vol. X, 1910)

Number.	Ingredients.	Per cent
W 147.....	Basic sulphate, white lead in oil.....	75.0
	Zinc oxide in oil.....	25.0
W 5	Basic carbonate, white lead.....	25.0
	Basic sulphate, white lead.....	20.0
	Zinc oxide.....	45.0
	Calcium carbonate.....	10.0
W 149	Basic carbonate, white lead.....	67.0
	Zinc oxide.....	19.05
	Asbestine.....	3.5
	Calcium carbonate.....	10.0
W 7	Basic carbonate, white lead.....	48.5
	Zinc oxide.....	48.05
	Calcium carbonate.....	3.0
W 176.....	Zinc oxide.....	30.0
	Special silica.....	30.0
	Basic carbonate, white lead.....	15.0
	Basic sulphate, white lead.....	25.0
W 9	Basic carbonate, white lead.....	22.0
	Zinc oxide.....	50.0
	Calcium carbonate.....	2.0
	Aluminum and magnesium silicates.....	26.0
W 175.....	Basic carbonate, white lead.....	38.95
	Lead sulphate.....	4.81
	Zinc oxide.....	33.58
	Calcium carbonate.....	19.48
	Barytes and silica.....	3.18
W 11	Zinc oxide.....	64.0
	Barytes.....	36.0
W 180.....	White lead.....	37.5
	Lead sulphate.....	7.84
	Zinc oxide.....	25.87
	Calcium carbonate.....	20.36
	Barytes and silica.....	8.42
W 13	Basic carbonate, white lead.....	43.0
	Zinc oxide.....	57.0
W 181.....	Basic carbonate, white lead (type B).....	100.0

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Number.	Ingredients.	Per cent
W 15	Basic carbonate, white lead	38.0
	Zinc oxide	48.0
	Silica	14.0
W 182	Basic carbonate, white lead (type C)	100.0
W 17	Zinc oxide	73.0
	Silica	25.0
	Calcium carbonate	2.0
W 177	Basic carbonate, white lead (type A)	100.0
W 19	Basic carbonate, white lead	44.0
	Zinc oxide	46.0
	Calcium carbonate	5.0
	Magnesium silicate	5.0
W 178	Zinc lead	100.0
W 21	Basic carbonate, white lead	50.0
	Zinc oxide	50.0
W 168	Sublimed white lead	100.0
W 23	Basic carbonate, white lead	60.0
	Zinc oxide	34.0
	Inert pigment	6.0
W 170	Zinc oxide	90.0
	Calcium carbonate	10.0
W 25	Basic sulphate, white lead	60.0
	Zinc oxide	27.0
	Magnesium silicate	10.0
	Calcium carbonate	3.0
W 169	Zinc oxide	61.0
	Barytes	39.0
W 27	Basic carbonate, white lead	25.0
	Basic sulphate, white lead	20.0
	Zinc oxide	25.0
	Calcium sulphate	25.0
	Calcium carbonate	5.0
W 172	Zinc oxide (ground in special oil)	100.0

112 REPORT OF COMMITTEE D-1 (Proc., Vol. X, 1910)

Number.	Ingredients.	Per cent.
W 29	Zinc-lead white.....	30.0
	Zinc oxide.....	40.0
	Basic carbonate, white lead.....	20.0
	Calcium carbonate.....	10.0
W 31	Basic carbonate, white lead.....	33.0
	Zinc oxide.....	33.0
	Barytes.....	34.0
W 16	Basic carbonate, white lead.....	38.0
	Zinc oxide.....	48.0
	Silica.....	14.0
W 18	Zinc oxide.....	73.0
	Silica.....	25.0
	Calcium carbonate.....	2.0
W 20	Basic carbonate, white lead.....	44.0
	Zinc oxide.....	46.0
	Calcium carbonate.....	5.0
	Magnesium silicate.....	5.0
W 22	Basic carbonate, white lead.....	50.0
	Zinc oxide.....	50.0
W 24	Basic carbonate, white lead.....	60.0
	Zinc oxide.....	34.0
	Inert pigment.....	6.0
W 26	Basic sulphate, white lead.....	60.0
	Zinc oxide.....	27.0
	Magnesium silicate.....	10.0
	Calcium carbonate.....	3.0
W 28	Basic carbonate, white lead.....	25.0
	Basic sulphate, white lead.....	20.0
	Calcium sulphate.....	25.0
	Zinc oxide.....	25.0
	Calcium carbonate.....	5.0
W 30	Zinc-lead white.....	30.0
	Zinc oxide.....	40.0
	Basic carbonate, white lead.....	20.0
	Calcium carbonate.....	10.0

ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. 113

Number.	Ingredients.	Per cent.
W 32	Basic carbonate, white lead	33.0
	Zinc oxide.....	33.0
	Barytes.....	34.0
W 34	Barytes.....	13.0
	Blanc fixé.....	4.0
	Asbestine.....	3.0
	Zinc oxide.....	43.0
	Basic carbonate, white lead	37.0

We understand that this is to be the final official inspection of the fence, and recommend that the Sub-Committee be discharged.

Respectfully submitted,

ROBERT JOB,
Chairman, Sub-Committee C.

REPORT OF SUB-COMMITTEE E ON LINSEED OIL.

The Sub-Committee on February 4, 1910, sent the following letter to all the manufacturers of linseed oil in the United States, enclosing with this letter a copy of the report of Committee E* as reported at the last annual meeting:

"On behalf of Committee E of the American Society for Testing Materials, I am sending you a copy of its report as presented at the last meeting of the Society. I would call your special attention to the report of the Sub-Committee on Linseed Oil. This linseed-oil report contains a large amount of information which should be of value to the linseed-oil industry. May I ask you, after reading this report, to write me on the following points:

"First: Would you be willing to accept the specifications suggested by this Committee, on page 164, for American linseed oil? Also, would you accept them for oil made from imported seed?

"Second: How far would you advise on, or be willing to agree to, specifications for quality of linseed oil based on the tests for turbidity and foots, the moisture and volatile matter, and the free acid number? Any suggestions you may offer on this point will be appreciated.

"Third: Many of the tests which are included in the work of this Committee were found to give discordant results. We refer particularly to the acetyl value, hexabromide, and oxygen absorption tests. It is to be hoped that we can get some of our universities and colleges to investigate these tests and develop scientific methods. Any influence you may exert or suggestions you can offer in this direction would be very helpful to the Committee's work.

* This committee is now designated Committee D-1.—Ed.

"Fourth: How far would a flash point test be advisable for either purity or quality?

"Fifth: What would you advise as to specifications for boiled linseed oil? Should a boiled oil contain any rosin or rosin derivatives as shown by the Liebermann-Storch test? And what percentage of rosin would you permit? Should the amounts of lead and manganese present be specified? Also, should boiled-oil specifications have a minimum specific gravity? What would you advise that this minimum should be?

"If there are any other matters relative to this subject on which you would care to comment, we wish you would kindly do so."

This letter was followed up with other letters urging a reply, and we also had published in the technical trade papers a statement containing inquiries similar to the above, and giving our provisional recommendations of specifications for the purity of raw linseed oil and the methods to be used for testing.

Some communications have been received in reply to these letters, etc., from which we would draw the following conclusions:

The manufacturers of linseed oil think it better that more work should be done on the examination of linseed oil from different crops of seed before adopting specifications. It has been suggested by some that our specifications are too rigid and that the linseed oil made from the 1909 crop of flaxseed is lower in iodine number than that of the prior year. In accordance with this suggestion we are having samples taken of the linseed oil crushed from the 1909 crop of seed and will have these tested as soon as practicable. We also hope to have current samples taken during the crushing of the 1910 crop of seed to note whether variations in the oil produced occur with the age and maturity of the seed.

There seem to be reasonable grounds for expecting that specifications for the quality of linseed oil based on tests for turbidity, foots, moisture, volatile matter, and acidity, would be acceptable to the manufacturers of linseed oil and would be valuable to the consumer.

The large consumers of linseed oil have not so far communicated with the Sub-Committee expressing their views on the above questions as fully as could be desired. The Sub-Committee will endeavor to secure from consumers during the coming year more cooperation in this work.

There seems to be some difference of opinion as to the desirability of permitting the presence of rosin in boiled linseed oil; but there is reasonable agreement that the amount of rosin permissible should be limited. There is fair agreement that rosin oil and mineral oil should not be permitted at all. The Sub-Committee will give these matters very careful consideration, and it is hoped that in due time the question of specifications for boiled oil will reach a satisfactory conclusion.

Portions of the samples of oil taken in 1909 from the 1908 crop of seed have been furnished various investigators who have agreed to study these samples for the purpose of endeavoring to develop better methods of determining the acetyl value, hexabromide number, drying value, oxygen absorption tests, etc. Other portions of these samples are still available to investigators who desire to give them careful examination.

Respectfully submitted on behalf of the Sub-Committee,

G. W. THOMPSON,
Chairman.

REPORT OF SUB-COMMITTEE G ON THE INFLUENCE OF
PIGMENTS ON CORROSION.

June 15, 1910.

MR. S. S. VOORHEES,
Chairman, Committee D-1, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

At a meeting of Sub-Committee G, appointed to consider the influence of pigments on corrosion, the possible factors which enter into the problem were discussed and the methods proposed for measuring the influence of pigments on corrosion were fully considered. It was decided that relatively large quantities of ten representative pigments available for use in paints for the protection of iron and steel be obtained, and that each member of the Sub-Committee be supplied with samples of these pigments both in the dry state and when ground in linseed oil. Each member of the Sub-Committee will then subject these pigments to corrosion tests by the method which he considers most promising. The results of the individual members will remain unbiased by the results of other members, and a year from now the combined results will form the basis of a report.

Yours very truly,
(Signed) W. H. WALKER,
Chairman, Sub-Committee G.

REPORT OF SUB-COMMITTEE I ON VARNISH.

PHILADELPHIA, PA., June 14, 1910.

MR. S. S. VOORHEES,

Chairman, Committee D-1, American Society for Testing Materials,
Washington, D. C.

Dear Sir:

In accordance with your request, I take pleasure in submitting on behalf of Sub-Committee I the following summary of the Sub-Committee's report which was submitted to the full Committee:

Sub-Committee I has addressed a number of varnish manufacturers and technical consumers, setting forth the desire of the Committee to devise a form of specifications for varnish which will, on the one hand, enable the manufacturer to understand the requirements of the consumer, and which, on the other hand, will enable the consumer to ascertain within a reasonable degree of accuracy how closely such specifications have been fulfilled. Much interesting information has been collated from these sources, and there is promise that practical results will be obtained therefrom. During the coming year, the Sub-Committee will endeavor to formulate this information and place it before a select number of experts for practical test.

This report, therefore, is merely a report of progress, but the Sub-Committee hopes by the time of the next meeting to have information of value to lay before the members.

Yours very truly,

G. B. HECKEL,

Secretary, Sub-Committee I.

[For Discussion of this Report, see page 87.]

REPORT OF COMMITTEE A-5 ON THE CORROSION OF IRON AND STEEL.

The work of the Committee during the past year has consisted in the care and supervision of the wire-fence panels at Pittsburgh and the official inspection of the steel panels at Atlantic City. A sufficient time has not yet elapsed to justify a report on the wire tests, so that only the results obtained on the steel plates will be presented at this time.

A brief history of the Atlantic City steel test panels will make the results obtained more interesting to those members of the Society who have not closely followed the work of the Committee. Three years ago the suggestion was made in a paper presented before the Tenth Annual Meeting of this Society,* that the various types of substances used as pigments in protective coatings might exert a stimulative or an inhibitive action on the rate and tendency to corrosion of the underlying metal. It was further suggested on theoretical grounds that slightly soluble chromates should exert a protective action when employed as pigments, by maintaining the surface of the iron in a passive condition in case water and oxygen penetrated the paint film. In view also of the well-known fact that alkalis inhibit while acids stimulate the corrosion of iron, it was suggested that the action of more or less pure pigments on iron in the presence of water should be thoroughly investigated. Two years ago this Committee invited the cooperation of Committee D-1 (then known as Committee E) in the investigation, and a special sub-committee representing the two main committees was appointed.

The methods and results of the water-pigment tests have previously been reported and published,† and need not be given in detail. Briefly, the method consisted in immersing samples of steel in water suspensions of the various pigments and blowing air through the containers for definite periods of time, the corrosion

* "The Corrosion of Iron:" Allerton S. Cushman. *Proceedings*, 1907, Vol. VII, pp. 211-228.

† See Report of Committee E, Appendix II, *Proceedings*, 1909, Vol. IX, p. 203. See also, Bulletin No. 35, Office of Public Roads; also, Bulletins Nos. 7 and 18, Scientific Section, Paint Manufacturers' Association of the United States.

being measured by the loss in weight sustained by the test pieces. About fifty pigments which are in more or less common use for painting steel were purchased in the open market and distributed among a number of the members of the Committee, who agreed to carry out the work. Each investigator worked independently of the others, except that the same general method was followed; the time of exposure to the corroding action, however, varied in the different experiments. When the results were compared and analyzed by the sub-committee, it was felt that the general agreement of the results obtained by the several investigators was striking and merited further and more systematic work. As a result of these tests the sub-committee tentatively divided the pigments into inhibitors, stimulators, and indeterminates. The word "indeterminate" was selected after considerable discussion, because the words "neutral" or "inert" already possess a special meaning as applied to paint technology. The Committee takes this occasion to emphatically state that in adopting this tentative classification, the words "inhibitive" and "stimulative" as used by them up to the present time apply only to the results obtained in the water tests, and the inference that the results obtained have decided which class the pigment will fall into when made into a paint with the usual vehicles and used as a protective coating on iron and steel, is not justified. In order to make this point quite clear, it has been agreed by the Committee to qualify the classification so as to speak of the various materials tested as "water stimulative" or "water inhibitive."

As a result of the preliminary tests, it seemed desirable to the Committee that a systematic investigation of the same pigments should be made under service conditions. The Paint Manufacturers' Association of the United States offered to erect a series of steel panels at Atlantic City and place them under the supervision and control of this Society. The panels were erected in the autumn of 1908 and are now open to the inspection of members. The first official inspection was conducted by the special sub-committee on April 15, 1910. In order to carry out the inspection effectively, a committee of seven inspectors was appointed, each member of which was requested to make an independent inspection and turn in the results to the chairman. The method of examination adopted was as follows: Each plate was given two

TABLE I.—FIRST INSPECTION OF PAINT-TEST STEEL PANELS, ATLANTIC CITY, N. J.
by Sub-Committee D of Committee D-1.

	Green (composite paint)	Cor. Con.	6	8	9	9	8	5	9	7	9	8	7.7 7.3	9	5
555	Black (composite paint)	Cor. Con.	8	9.5	8	8	10	9	8	10	8	9	9.1 8.7	10	8
666	Brown (composite paint)	Cor. Con.	8	10	8	8	10	8	8	10	8	9	9.0 8.4	10	8
777	White (composite paint)	Cor. Con.	7	9.5	8	8	10	9	8	10	7	10	9.1 7.7	10	7
888	Green (composite paint)	Cor. Con.	8	10	8	8	10	10	9	10	8	10	9.4 8.3	10	8
2000	1 coat zinc chromate, 1 coat iron oxide excluder	Cor. Con.	9	10	10	8	9	5	9	10	8	6	8.4 7.4	10	5
3000	1 coat red lead, 1 coat iron oxide excluder	Cor. Con.	7	8	10	7	10	5	7	8	6	8	7.7 6.5	10	5
4000	1 coat red lead	Cor. Con.	7	9.5	8	7	10	8	7	9	6	8	8.5 7.5	10	8
100	Straight carbon black paint with turps and dryer	Cor. Con.	4	9	7	7	10	7	10	10	8	10	7.8 8.0	10	4
90	Straight lamp black paint with turps and dryer	Cor. Con.	6	9.5	7	7	10	9	10	10	7	9	8.3 8.1	10	6
5555	Coal tar paint (over red lead)	Cor. Con.	7	6	0	0	5	0	8	8	4	4	4.3 2.3	8	0
1000	Chrome resinate in oil, 1 coat.	Cor. Con.	4	7	0	0	4	0	6	6	2	2	3.0 3.0	7	0
1 (plate)	Boiled linseed oil 3 coats linseed	Cor. Con.	4	7	0	0	9	0	0	0	0	0	2.8 2.2	9	0

* Cor. signifies corrosion of plate

† Con. signifies condition of preservative coating.

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separate marks graded upon a scale of ten, one mark to signify the condition of the plate as far as effects of corrosion were discernible, and the other to grade as nearly as possible the present condition of the protective coating. In judging condition, various factors were taken into account, such as chalking, checking, cracking, scaling, and color. It was the unanimous opinion of the inspectors that so little difference existed in the duplicate panels on the different steels and fences, that a careful report on one line of panels would answer for all up to the present time. The results of the inspection are presented in Table I, showing the values given by each inspector, as well as the average, maximum, and minimum for each panel.

The original object of these tests was to determine whether the results obtained under service conditions bear any relation to the inhibitive and stimulative effects obtained in the laboratory water tests which have been previously described and published. For the convenience of those members who are interested in a comparison of the results of the two tests, two additional tables are

TABLE II.—ANALYSIS OF AVERAGES. GRADE OF EXCELLENCE
FROM 8 TO 10.

(Only resistance to corrosion was considered, and only pigments which were common to both tests are included.)

No.	Pigment.	Average.
34	American vermilion (chrome scarlet)*	9.8
41	Chrome green (blue tone).....	9.8
40	Zinc and barium chromate.....	9.7
5	Sublimed blue lead.....	9.6
4	Sublimed white lead.....	9.5
49	Zinc and lead chromate.....	9.5
39	Zinc chromate.....	9.4
12	Bright red oxide.....	9.3
44	Prussian blue (water stimulative).....	9.2
16	Natural graphite.....	9.1
9	Orange mineral (American).....	9.0
36	Medium chrome yellow.....	9.0
2	White lead (quick process).....	8.9
20	Willow charcoal.....	8.8
45	Prussian blue (water inhibitive).....	8.8
1	White lead (Dutch process).....	8.7
10	Red lead.....	8.7
7	Zinc lead white.....	8.0

* Average of six, leaving out W. H. Walker's low value of 5, which was evidently in error. This action was authorized by vote in committee.

appended. Table II gives in order all the simple pigments that attained an average of from eight to ten in the exposure tests on the steel panels. Table III gives in order the pigments which had the highest inhibitive effects in the water test. It is the opinion of the Committee that the panel tests have not progressed far enough

TABLE III.—CHART OF FINDINGS OF MEMBERS OF COMMITTEES D-1 AND A-5.

Loss of Steel in Grams in Tests Carried Out on Pigments to Ascertain Their Value as Rust Inhibitors.

No.	Pigment.	Gardner. No. 1, 20 days.	Cushman. Nos. 1 and 2, 10 days.	P. Walker. No. 2, 7½ days.	Cushman. No. 2, 10 days.	W. Walker. No. 1.	Average.
1	Zinc chromate.....	0.0050	0.0300	0.0094	0.0130	0.0396	0.0194
2	Zinc and barium chromate.....	0.0153	0.0468	0.0034	0.0140	0.0351	0.0229
3	Zinc and lead chromate.....	0.0094	0.0277	0.0153	0.0085	0.0620	0.0246
4	Zinc oxide.....	0.1524	0.0296	0.1002	0.0085	0.0504	0.0682
5	Zinc lead white.....	0.0842	0.1712	0.0515	0.0856	0.0456	0.0876
6	Barium chromate.....	0.2333	0.0101	0.0429	0.0094	0.1932	0.0978
7	Ultramarine blue.....	0.0247	0.3185	0.0137	0.1865	0.0496	0.1186
8	Chrome green (blue tone).....	0.0860	0.2269	0.0548	0.1240	0.2246	0.1453
9	Prussian blue (water inhibitive).....	0.1438	0.2267	0.0448	0.1130	0.2671	0.1501
10	Lithopone.....	0.0160	0.3791	0.1274	0.1792	.....	0.1754
11	Willow charcoal.....	0.1694	0.2795	0.1439	0.1362	0.2110	0.1880
12	Litharge.....	0.4325	0.1932	0.0309	0.1584	.....	0.2038
13	Dutch process white lead.....	0.2040	0.2895	0.1781	0.1150	0.2743	0.2122
14	Quick process white lead.....	0.2120	0.3352	0.1238	0.1848	0.2274	0.2176
15	Calcium sulphate.....	0.3966	0.2143	0.1759	0.1597	0.2174	0.2328
16	Metallic brown.....	0.3774	0.2620	0.1983	0.1408	0.1974	0.2352
17	Orange mineral (French).....	0.3650	0.2724	0.1495	0.1467	0.2526	0.2432
18	Calcium carbonate (whiting).....	0.3828	0.3620	0.1384	0.2380	0.1208	0.2484
19	Sublimed blue lead.....	0.3177	0.3425	0.1001	0.2365	.....	0.2492
20	Lemon chrome yellow.....	0.2767	0.4067	0.1365	0.1972	.....	0.2543
21	Orange chrome yellow.....	0.2826	0.4203	0.1700	0.1907	0.2150	0.2557
22	Medium chrome yellow.....	0.4090	0.3767	0.1319	0.1763	0.2288	0.2645
23	Chrome green.....	0.3265	0.3670	0.1348	0.1453	0.3521	0.2651
24	Venetian red.....	0.2682	0.4756	0.1955	0.2375	0.1564	0.2666
25	Bone black.....	0.3392	0.3245	0.0921	0.1413	0.4401	0.2674
26	Asbestine.....	0.2394	0.4025	0.1748	0.2240	0.3405	0.2762
27	Keystone filler.....	0.3560	0.4651	0.1366	0.3349	0.1481	0.2881
28	Orange mineral (American).....	0.4416	0.4836	0.1719	0.2065	0.2315	0.2970
29	Umber.....	0.1365	0.5961	0.1498	0.3817	0.2403	0.3009
30	China clay.....	0.3493	0.4770	0.1248	0.2445	0.3212	0.3034
31	Calcium carbonate (precipitated).....	0.3574	0.4910	0.1828	0.2625	0.2616	0.3111
32	Red lead.....	0.3112	0.3555	0.1495	0.1717	0.5707	0.3117
33	Prussian blue (neutral).....	0.3584	0.4463	0.1218	0.2415	0.4173	0.3171
34	Indian red.....	0.3546	0.3739	0.2617	0.1906	0.4334	0.3228
35	American vermilion.....	0.4328	0.4147	0.2612	0.1877	0.3387	0.3270
36	Sublimed white lead.....	0.4176	0.5856	0.0982	0.2372	0.3116	0.3300
37	Sienna.....	0.2876	0.5432	0.2949	0.3085	0.4462	0.3761
38	Naples yellow.....	0.0482	0.4800	0.1512	0.2347	0.2846	0.3797
39	Prussian blue (water stimulative).....	0.5113	0.4559	0.2055	0.2195	0.5202	0.3825
40	Mineral black.....	0.3050	0.8018	0.2017	0.3529	0.3353	0.3983
41	Barytes.....	0.4454	0.5883	0.2547	0.3941	0.5636	0.4472
42	Natural graphite.....	0.4342	0.5437	0.2606	0.3173	0.7165	0.4545
43	Bright red oxide.....	0.3878	0.7896	0.2920	0.3707	0.4429	0.4566
44	Artificial graphite.....	0.5262	0.6337	0.3723	0.2789	0.5095	0.4641
45	Ochre.....	0.4022	0.8408	0.2119	0.4315	.....	0.4716
46	Carbonith white.....	0.2655	.....	.....	.....	0.7152	0.4904
47	Carbon black.....	0.5003	0.6955	0.4069	0.3751	0.5716	0.5099
48	Precipitated blanc fixe.....	0.5247	0.8806	0.3132	0.5085	0.5064	0.5467
49	Lampblack.....	0.7180	1.3098	0.2838	0.7096	0.6257	0.7294

as yet to justify definite conclusions being drawn. It is not only possible but probable, that in the course of time many of the plates that are at present in good condition will begin to fail and fall below others which now show slight deterioration. It is at once apparent, however, from an inspection of these tables, that those pigments whose protective value depends upon the principle of chromate inhibition, as well as those which produce basic reactions in water suspensions, have given a good account of themselves on the steel panels. In Table II, out of eighteen pigments common to both series of tests, there are but five exceptions to the above statement, represented by Pigments Nos. 5, 12, 44, 16 and 7.* All these pigments are claimed to be good excluders and do not depend upon solubility in water, and consequently on any inhibitive value, for the protection provided. Beyond calling attention to this point, the Committee prefers to refrain from drawing conclusions at this time from the results of these tests.

The Committee is unanimously of the opinion that up to the present time no differences are discernible in the duplicate protective coatings applied to different types of steel or to surfaces prepared in different ways. As would be expected, however, the panels which faced the ocean and acted to some extent as a wind break to the other lines, show slightly advanced deterioration.

In addition to the single pigments which were common to both series of tests, a number of composite paints were included. These composites were made up in part from water stimulatives and in part from water inhibitives. Both types, however, were to some extent reinforced with other pigments from the indeterminate class. Such results as have been obtained so far can be judged by an inspection of the tables.

It was the consensus of opinion in the Committee that the results of the inspection would be made more thorough by removing the paint films from one set of plates, so that the condition of the underneath surface could be examined. As there are six duplicate panels for all of the single pigments, the Committee felt that this could be afforded, and consequently this action was voted and a sub-committee appointed to carry out the work. The results obtained are now on exhibition at this meeting.

* Pigment No. 7, zinc lead white, might almost be considered a water inhibitor, owing to its content of ZnO (50 per cent.).

The report of the special sub-committee which had direct charge of the preparation, erection and painting of the steel test panels is appended to this report. The report gives information necessary to the proper understanding of all the details of the tests, and is, in the main, self-explanatory. One or two points, however, require further explanation. In some cases the general method adopted for making up the paints with a standard quantity of oil did not yield a proper painting consistency, which therefore necessitated the addition of a certain amount of turpentine. Special difficulties were encountered in the application of some of the black pigments, and in order to reduce these to a proper consistency they were used in combination with definite amounts of barytes. This was unfortunate, as it may completely destroy the comparative value of the tests as far as these black pigments are concerned. In view of the fact that none of the straight barytes panels, Nos. 27 and 28, escaped deterioration in the tests, it was manifestly unfair to the black pigments to mix them with this material. The results obtained on these particular panels should therefore be interpreted as applying only to the specific mixtures employed.

Respectfully submitted on behalf of the Committee,

W. H. WALKER,
Secretary.

A. S. CUSHMAN,
Chairman.

APPENDIX.

REPORT OF JOINT SUB-COMMITTEE IN CHARGE OF ERECTION AND PAINTING OF STEEL TEST PANELS AT ATLANTIC CITY.

All the pigments enumerated in Table IV were ground in quantities of the weight shown, in two thirds of a gallon, by measure, of raw linseed oil, and one third of a gallon of boiled linseed oil, without regard to consistency, as arranged. The resulting material was put up in one-quart friction-top cans, the covers of which were stamped with the letter "P" and a number, as per key given. The labels read "Pigment No. 1," and so on.

Preparation of Formulas.—The preparation of the formulas for the paints to be used in the field test required the determination of the specific gravity of the various pigments, and when this was accomplished a definite formula for the grinding was decided upon, so that the same amount by volume of each pigment would be used in the same quantity of oil, viz., specific gravity of pigment $\times 3$ = pounds of pigment to gallon of oil. It was decided to grind these pigments separately, in a mixture of two-thirds raw and one-third boiled linseed oil, no drier being included because of the unknown factor which would be introduced by the lead content of such drier.

Besides the pigments ground separately in oil, a series of composite paints was made. These paints were made up in part mainly from the water inhibitive and in part from the water stimulative types of pigments. The composition of these special paints is given in Table V.

Preparation of Plates.—Several hundred plates were obtained for the test and one half the number were pickled in sulphuric acid, then neutralized with soda ash, thoroughly washed, and preserved from future oxidation in dry lime until needed for the test. The removal of the mill scale was complete in the case of the pickled plates and a perfectly clean, neutral surface was obtained upon which to apply the paints.

Painting of Plates.—The painting of the plates was done under cover in a temporary building erected for the purpose. This

TABLE IV.—TABLE OF INFORMATION REGARDING PAINTS.

Pigment No.	Name of Pigment.	Wt. of Pigment per Gal. of Oil, lbs.	Sp. Gr. of Paint as Rec'd.	Grams of Paint to Panel at 900 sq. ft. spreading rate.
1	Dutch process white lead.....	20.49	2.45	61.0
2	Quick process white lead.....	20.34	2.47	62.0
3	Zinc oxide XX.....	16.68	2.12	*59.0
4	Sublimed white lead.....	19.17	2.36	59.0
5	Sublimed blue lead.....	19.17	2.42	61.0
6	Lithopone.....	12.78	1.80	45.3
7	Zinc lead white.....	13.26	1.96	49.4
9	Orange mineral (American).....	26.91	2.97	74.7
10	Red lead.....	26.10	2.93	73.6
12	Bright red oxide.....	15.78	2.05	†60.0
14	Venetian red.....	9.30	1.52	38.0
15	Metallic brown.....	9.51	1.50	37.7
16	Natural graphite.....	7.80	1.37	34.4
17	Artificial graphite.....	6.63	1.22	30.8
19	{ Lampblack.....	1.82 }	1.60	40.2
	{ Natural barytes.....	8.92 }		
20	Willow charcoal.....	4.47	1.08	27.0
21	{ Gas carbon black.....	1.39 }	1.67	‡50.7
	{ Natural barytes.....	10.03 }		
24	French yellow ochre.....	8.82	1.46	37.0
27	Barytes (natural).....	13.38	1.83	46.0
28	Barytes (precipitated).....	12.69	1.84	46.0
29	Calcium carbonate (whiting).....	8.22	1.37	34.5
30	Calcium carbonate (precipitated)....	7.68	1.35	34.0
31	Calcium sulphate (gypsum).....	6.99	1.25	31.4
32	China clay (kaolin).....	8.01	1.34	34.0
33	Asbestine (silicate of magnesium)...	8.25	1.38	34.7
34	American vermilion (chrome scarlet).	20.49	...	64.5
36	Medium chrome yellow.....	17.64	...	§67.1
39	Zinc chromate.....	10.71	1.57	39.2
40	Zinc and barium chromate.....	10.35	1.58	40.0
41	Chrome green (blue tone).....	13.32	1.94	49.0
44	Prussian blue (water stimulative)...	5.88	...	30.0
45	Prussian blue (water inhibitive).....	5.79	...	||34.5
48	Ultramarine blue.....	7.20	1.29	32.5
49	Zinc and lead chromate.....	14.28	1.92	48.3
51	Magnetic black oxide.....	15.00	1.92	48.3
COMPOSITE PAINTS.				
111	Brown	10.82	1.30	32.7
222	Black	10.86	1.30	32.8
333	White	14.52	1.744	43.8
444	Green	12.77	1.53	38.6
555	Black	9.37	1.125	28.0
666	Brown	11.74	1.41	35.5
777	White	14.55	1.75	44.0
888	Green	14.57	1.75	44.0

* 50.5+8.5. Thick paste, requiring 170 grams turpentine to thin 1,000 grams to working consistency, thus raising the amount per panel to 59 grams.

† 51.5+8.5. 1,000 grams paste required 166 grams turpentine.

‡ 42+8.72. 1,000 grams paste required 218 grams turpentine.

§ 56+11.1. 1,500 grams paste required 209 grams turpentine.

|| 29.5+5.0. 1,000 grams paste required 163 grams turpentine.

TABLE V.—COMPOSITION OF SPECIAL FORMULAS.

Pigment Formula.	Ingredients.	Paint Formula.	Pigment Formula.	Ingredients.	Paint Formula.
	No. 111.			No. 222.	
60	Burnt umber.....	22.50	30	Bone black.....	13.72
20	Zinc and Barium chromates.....	7.50	2	Prussian blue.....	0.92
20	Zinc lead.....	7.50	10	XX zinc.....	4.57
	Japan.....	3.40	50	Silex.....	22.86
	Raw oil.....	59.10	8	Calcium carbonate..	3.66
				Japan.....	8.33
				Raw oil.....	45.94
	No. 333.			No. 444.	
35	Zinc oxide.....	20.90	60	XX zinc.....	32.47
45	Zinc lead.....	26.87	15	Zinc chromate.....	8.30
5	Calcium carbonate..	2.98	3	Prussian blue I...	1.44
15	Silex.....	8.95	2	Calcium carbonate..	1.08
	Japan.....	1.56	20	Silex.....	10.83
	Raw oil.....	38.74		Japan.....	2.22
				Raw oil.....	43.66
	No. 555.			No. 666.	
40	Lamp black.....	8.18	50	Red oxide, 62 a	22.94
40	Natural graphite....	8.18	5	Carbon black.....	2.35
20	Barytes.....	4.09	35	Barytes.....	15.30
	Japan.....	8.33	10	Med. chrome yellow	5.88
	Raw oil.....	71.22		Japan.....	3.20
				Raw oil.....	50.33
	No. 777.			No. 888.	
60	Sublimed white lead.	44.80	5	Chinese blue S.....	4.32
20	Blanc fixé.....	7.46	35	Lemon chro. yellow.	18.94
20	Gypsum.....	7.46	20	Sublimed white lead.	16.23
	Japan.....	1.60	40	Barytes.....	21.35
	Raw oil.....	38.68		Japan.....	2.35
				Raw oil.....	38.51

was necessary in order to have uniform conditions for the application of each formula. A definite spreading rate of 900 sq. ft. to the gallon was used on the paints applied to the cleaned plates, while the paint applied to the black plates—i. e., those not pickled, and having the ordinary black mill scale—had no definite spreading rate. The paint was applied by the painters representing the Committee and the Master Painters' Association, under the constant supervision of the Director of Tests. Three-coat work was used throughout on the cleaned plates upon which the original fifty-one pigments were applied; but in some cases, on the black plates, where the special formulas were applied, two-coat work was used.

Details of Application.—After the specific gravity of the paint had been taken and the amount necessary for the application to each panel had been determined according to the spreading rate, a quart of paint was placed in a half-gallon enameled cup, and stirred well to bring the mixture to thorough incorporation. A brush was thoroughly worked into the paint, and pot and all were placed upon the balance and the weight taken in grams, using the metric system throughout the test. The pot was then handed to the painter, who applied the paint to one plate. The number of grams applied to each panel was deducted from the counterbalance, and when the pot, paint and brush exactly balanced, the panel was cross-brushed and laid out. The final weighing was then made to see that the counterbalance was maintained. The plates during the work were set upon a frame resting upon a bench, room being allowed beneath the plate for the painter to place his hands when lifting it, after the brushing had been finished. The plate was then taken from the bench and slid into a specially prepared rack, so that the paint would dry in a horizontal position. Racks for several hundred of these plates were built and used during the test.

A sufficient length of time between the coats was allowed for the thorough drying of each pigment. Extreme care was used in painting the edges of the plates, for the reason that corrosion generally starts at this point of attack. Each pigment was applied in duplicate to each class of steel, so that when set upon the fence, they could be placed in both an eastern and western exposure.

No reductions were made to any of the paints applied, except in one or two cases (see report), where the viscosity of the paint was so great that the possibility of brushing was precluded. A small amount of turpentine was added in these cases and the amount of paint to be applied to the panel proportionately increased, so that when the turpentine evaporated, the amount of paint originally intended would be left upon the plate.

Fences.—The fences upon which the steel plates were fastened after the painting are three in number, and each one is 125 ft. long and 5 ft. high. They are built of 4 by 4-in. yellow-pine studding, the posts being set 8 ft. apart, and strongly counterbraced underneath the surface of the ground with 2 by 4-in. pieces. A strip of 2-in. batton is provided along the lower beam on either side of

each fence, as a resting place for the plates. The plates rest on two small pieces of rawhide fastened 18 ins. apart on the battons, thus being raised a sufficient distance from the baton to prevent the accumulation of water at the bottom of the plates. The plates rest and back against the beams at top and bottom, and are fastened to these beams by metal buttons screwed into the wood between and lapping over an equal distance on two plates. Insulation of the buttons was obtained by interposing rubber strips between the plates and the button. The buttons were enameled and the screw heads painted and subsequently plugged with putty. This method of fastening the plates obviates the bad practice of drilling screw-holes through the plates, which invariably starts a place of corrosion. Each plate has, lettered upon its lower left-hand corner, the number of the paint or pigment with which it is painted, and a numeral to show the class of steel used. Below each plate, in order to secure permanent identification, these same numbers are stamped in the wooden fence.

BRIEF DESCRIPTION OF PIGMENTS USED IN TEST.

1. *Dutch Process White Lead*.—Made by the well-known old Dutch process of corrosion.

2. *Quick Process White Lead*.—Made by the quick process.

3. *Zinc Oxide XX*.—Made from sublimation of New Jersey zinc ores.

4. *Sublimed White Lead*.—Sublimed from Missouri lead ores.

5. *Sublimed Blue Lead*.—Made by burning coarsely broken galena mixed in a furnace with bituminous coal. The fumes arising from this complex mixture are streaked in appearance, white, blue and black. They are drawn from the furnace by suction fans, purified, and collected by suction in a bag room. The material varies considerably in composition, but its working properties are about constant. Its analysis will average about as follows:

Lead sulphate.....	50 per cent.
Lead oxide.....	35 "
Lead sulphide.....	5 "
Lead sulphite.....	5 "
Zinc oxide.....	2 "
Carbon.....	3 "

Its color is due to the carbon and lead sulphide.

6. *Lithopone*.—Manufactured by the double decomposition of zinc sulphate and barium sulphide, the resulting product being filter-pressed and furnaced, after which it is disintegrated while in its heated condition by plunging into water, where it is thoroughly washed and again filter-pressed. It is then dried and ground.

7. *Zinc Lead White*.—Analysis:

Lead sulphate	52.7 per cent.
Zinc oxide	47.2 "

Made by sublimation of sphalerite and galena in the proper proportion, the fumes of which are oxidized and collected in bags.

9. *Orange Mineral (American)*.—Made from white lead by the usual method.

10. *Red Lead*.—Made by oxidizing litharge in reverberatory furnaces.

12. *Bright Red Oxide*.—Ninety-eight per cent. oxide of iron (copperas red).

14. *Venetian Red*.—Made by calcining a mixture of copperas and terra alba.

15. *Metallic Brown*.—Made by roasting ore mined in Carbon County, Pennsylvania, for 72 hours at a cherry-red heat, thus changing the iron from the carbonate to the sesquioxide. After the ore is roasted, it is simply ground and is then ready for mixing. Impurities consist of silica and alumina. Analysis of this product runs approximately:

Iron	45 per cent.
Silica (SiO_2)	45 "
Alumina (Al_2O_3)	10 "

16. *Natural Graphite*.

17. *Artificial Graphite*.—Ninety per cent. pure carbon. The ash contains carbide of silicon, a small percentage of silica, iron and aluminum.

19. *Lampblack*.—Ninety-nine per cent. pure carbon, one per cent. ash and volatile matter. Passed United States Government specifications. Made from creosote and refuse oils.

20. *Willow Charcoal*.—From calcination of willow branches. Contains trace of potash.

21. *Carbon Black*.—From combustion of natural gas. Approximates 99 per cent. carbon.

24. *Yellow Ochre*.—Hydrated silicate of iron and alumina.

27. *Barytes*.—Best grade of thoroughly washed, floated barytes. Analysis:

Barium sulphate.....	99.66 per cent.
Oxide of iron.....	0.01 “
Lime.....	0.02 “
Silica.....	0.22 “
Moisture.....	0.09 “
Magnesia.....	Trace
Sulphuric acid free.....	Trace

28. *Precipitated Blanc Fixé*.—Made by the precipitation of barium chloride and sodium sulphate. May contain traces of sodium sulphate.

29. *Calcium Carbonate (whiting)*.

30. *Precipitated Calcium Carbonate*.—Made by the precipitation of calcium chloride and sodium carbonate. May contain trace of alkali.

31. *Calcium Sulphate*.—Natural.

32. *China Clay*.

33. *Asbestine*.—Silicate of magnesium.

34. *American Vermilion*.—Made by boiling white lead and chromate of soda and adding a small quantity of sulphuric acid in order to brighten the shade. This color consists of basic chromate of lead in large crystallized form. It is liable to contain free chromates, small quantities of white lead and sulphate of lead; also small quantities of sulphate of soda.

36. *Medium Chrome Yellow*.—This is pure neutral chromate of lead made from nitrate of lead and chromate of soda. It is practically free from impurities and contains only very minute traces of lead salts and nitrate of soda.

39. *Zinc Chromate*.—This is manufactured from a zinc salt and bichromate of potash. Owing to its solubility, it is impossible to wash perfectly, and it contains, therefore, usually a considerable amount of soluble matter, sulphate of potash, chromates, and zinc oxide.

40. *Zinc and Barium Chromate*.—This was made by precipitating a mixture of zinc chloride and barium chloride with

chromate of soda. The remarks under No. 39 apply here also. The product contains considerable soluble matter, consisting of zinc chloride, barium chloride, sodium chloride and chromates.

41. *Chrome Green, Blue Shade*.—This was made from nitrate of lead, bichromate of soda, and oil of vitriol, precipitated on white lead and Chinese blue. Beside chromate of lead, the resultant product contains sulphate of lead, Chinese blue, and white lead. It is liable to contain nitrate of lead salts and nitrate of soda.

44. *Prussian Blue, Water Stimulative*.—This is a Chinese blue, made from prussiate of potash and copperas. It was oxidized with chloride of lime. The resulting product contains small quantities of chlorides.

45. *Prussian Blue, Water Inhibitive*.—This is a Prussian blue made from prussiate of potash and copperas. It was oxidized with bichromate of potash. It contains a certain amount of chromates, to which its water inhibitive qualities are probably due.

48. *Ultramarine Blue*.—Made from silica, china clay, soda ash, and sulphur, combined chemically by burning in pots in furnaces, the resulting product being ground, bolted, etc. Analysis of this product shows the presence of the above compounds.

49. *Zinc and Lead Chromate*.—This was made from zinc and lead acetates and chromate of soda. It contains small quantities of zinc and lead acetates and of chromates, also of acetate of soda.

51. *Magnetic Oxide of Iron*.—Not, properly speaking, a magnetic oxide. Made by neutralizing acid ferrous sulphate liquors with an alkali and blowing air through.

Respectfully submitted on behalf of the Joint Committee,

H. A. GARDNER,
Chairman.

JOINT DISCUSSION OF REPORTS OF COMMITTEES A-5 AND D-1.

MR. A. S. CUSHMAN.—I am sure that every one who has inspected the Atlantic City steel test plates even so short a time ago as April 15, has found that a great change has taken place upon them in these last two months, so that if the official inspection were to be made to-day I am sure that there would be certain changes necessary in the grading as given in this official report. If the life of a paint coating could be represented graphically, it would show a rather straight curve for a certain time, which would then suddenly drop off. In other words, when failure of a coating is once discernible it goes on rapidly to destruction. Mr. Cushman.

THE PRESIDENT.—It should be a source of very great gratification to the Society to find that this excellent and important work is being done with such thoroughness. The importance of it is really very hard to grasp. Considering the enormous amount of exposed iron surfaces throughout the world, the matter of properly protecting the same is obviously one of very great moment. That it should be taken up so systematically, so thoroughly, and so laboriously by our sub-committees should be a matter of great pride to us, and of gratitude to the sub-committees which have done this work. The President.

MR. C. M. CHAPMAN.—I should like to ask if the Committee is including in its report any statement of a difference between plates which were pickled and those which were black. Mr. Chapman.

MR. CUSHMAN.—The Committee is unanimously agreed that so far as our knowledge goes at the present time, there is no difference discernible in any of the duplicate plates, whether they are different steels or whether they are differently prepared surfaces; but you will please note, *up to the present time*. Mr. Cushman

MR. S. S. VOORHEES.—In that connection I would say that in the report made by Mr. Aiken on the Havre de Grace bridge, it is noted that paints on the specially prepared plates are apparently not in such good condition as on the bridge proper. These plates were pickled. If this superiority is maintained on continued Mr. Voorhees.

Mr. Voorhees. exposure, the treatment of the plates prior to painting will require further investigation. In talking to Mr. Gibbs of the Pennsylvania Railroad last evening, he told me that it is no longer the practice to pickle the steel plates used in steel-car construction; they have given that up, and are sand-blasting instead.

Mr. Chapman. **MR. CHAPMAN.**—I should like to emphasize one point. Our experience in testing paints has indicated that the black scale which is tight on the plate is a pretty good protector in itself. If one can remove the loose scale and leave the tight scale, the result will be increased protection against rust.

Mr. Tassin. **MR. WIRT TASSIN.**—I have found in every case that the pickled plate which had not been baked but simply neutralized by putting it in limewater presented anomalies which were not characteristic of the pickled plate that had been baked. I found that those plates which had not been pickled, or which had been simply pickled a little, not only had a very much better surface for holding pigments, but seemed not to possess anomalies characteristic of the pickled plates which had not been baked.

Mr. Cushman. **MR. CUSHMAN.**—Does not baking the plate put a skin of blue oxide on the surface again?

Mr. Tassin. **MR. TASSIN.**—Always.

Mr. Cushman. **MR. CUSHMAN.**—Then if you bake you are really making an oxidized surface, only you are making a more even coating of the blue oxide? In my opinion the hydrogen which produces blistering of a paint coating is not that which is absorbed by the iron during pickling, but that which results from the electrolysis which is a concomitant of the action which goes on whenever and wherever iron rusts.

Mr. Tassin. **MR. TASSIN.**—We know that the pickling itself has an action on the physical properties of the steel; in other words, there is a certain amount of hydrogen occluded in the steel which must be given off at some period of time. I assume that that also has something to do with the continuity of the film; that is, this hydrogen, passing out through the pores, would eventually get to the surface, and of course baking drives that out immediately.

Mr. Walker. **MR. P. H. WALKER.**—I should like to call the attention of the members to a mistake which I made in the inspection of the fence referred to by Mr. Cushman. The mistake was in the marking of the plate painted with vermilion. My original mark

was No. 5, and when I saw I was absolutely in the minority, I **Mr. Walker.** assumed that it was perhaps a clerical error. I went to the plate yesterday and made another careful inspection. When I first looked at it I came to the conclusion that I was not in error, and as well as I could tell with the naked eye, my original mark would have stood. I then examined this plate carefully with a lens. It has on it a number of spots that looked to me like rust, and even with the lens it still had that appearance. I was very much puzzled to find how the other men had missed it. It then occurred to me to wash the plate, whereupon I found that the discoloration was entirely on the top of the paint film. I do not know what the material is, unless possibly it is coal dust. If I were required to grade that paint again, I should grade it No. 10.

A MEMBER.—I should like to ask how those plates were **A Member.** cleaned.

MR. H. A. GARDNER.—Do you refer to the pickling of the **Mr. Gardner.** plates, or the cleaning off of the paint? The plates were all removed from the fence and taken in the presence of the Inspection Committee to a small shed. After one-half the painted surface had been covered with a board, the remaining surface was cleaned with a paint-remover made of acetone, benzol and wax. This was brushed on the surface, and after ten minutes the paint was loosened to such an extent that it could easily be removed with a 3-in. scraping knife. The films came off in long strips about 3 ins. wide, leaving the bare surface of the metal, which in some cases was corroded and in other cases was perfectly clean. In some instances the strips of paint when removed had on their surfaces very large areas of corrosion which adhered to the film itself. In one case (basic carbonate, white lead) I took a photograph of the film with the adhering rust, which was very thick. On some plates the corrosion was very thick, and on others there was no corrosion at all.

MR. CUSHMAN.—I think Mr. Gardner should have added, **Mr. Cushman.** for the information of the members, that as soon as the paint films were removed from half the panels the plates were quickly dried, and then given a coat of thin shellac dissolved in alcohol. This was done to preserve the plates for the time being so that no superficial rust would appear on those surfaces until the members present had an opportunity to complete their inspection. It is

Mr. Cushman. not to be supposed that a single coat of shellac will preserve the surfaces indefinitely.

Mr. Carpenter. MR. A. W. CARPENTER.—I have had an opportunity, in the last four or five years, to make quite a few tests with paint coatings on steel plates, and one thing which impressed me when looking at these plates on the fence was that they were painted with three coats in apparently the most excellent manner, and yet, after an exposure of only about twenty months, these coats are in many cases going to pieces, or showing defects. In the atmosphere of New York City such coatings, I venture to say, would show up better with even two or three times that length of exposure. I do not know whether the point has been brought out before that the atmosphere of Atlantic City is evidently an unusual one. I think that is a point which possibly might and should be taken into account in judging the results of these tests. The results may not be applicable to ninety-nine per cent. of the territory of the United States.

Mr. Voorhees. MR. VOORHEES.—I think that point was considered when making a comparison of the plates at the Havre de Grace bridge, which have been up five years, with the plates here, which have been up only about a year and a half. In many cases the plates at Havre de Grace are in better condition than the plates here.

Mr. Cushman. MR. CUSHMAN.—I should like to say in this connection, that although it is true that Atlantic City presents accelerative conditions, it was just for that very reason that Atlantic City was selected as the place to erect the test panels. Some of us are getting old and we might die before we learn anything. Then again, I wish to make the point that in many cases things look well on the outside but—it is the old whited sepulchre over again—are rotten underneath. I understand that in these tests, there is no intention or desire on the part of the Committee—and in voicing the feeling of the Committee I believe I am speaking for the entire American Society for Testing Materials—to make any invidious comparisons between different materials for paints to be applied to iron and steel. We are endeavoring to do something better than that; we are studying principles. We want to ascertain if it is true that a paint coating may look quite well for a number of years, yet allow corrosion to start underneath, so that the time soon comes when it rapidly fails and goes to pieces. We want to see if it is

possible to so design our paint, that if it is properly applied it will not only present a good appearance on the outside, but will also preserve the surface of the steel that it covers. If we can do this—I do not say that we have already accomplished this, although we have in my personal opinion made several steps in the right direction—we will have achieved something from these tests that will repay all of the arduous work that has been done by those who have put their time and thought into it. **Mr. Cushman.**

MR. GARDNER.—On several of the paints I noticed small blisters appearing, and at first I thought these blisters might have been caused by occluded hydrogen in the metal, which had developed during the pickling process; but I concluded later that these blisters were due to another cause, as they all appeared on panels which were painted with pigments of the water stimulative type. I reasoned that the moisture going through the paint film would act on the iron in the presence of oxygen and cause corrosion, and the hydrogen which was developed would be de-polarized by the painted surface, and then the de-polarized hydrogen would form the little nodules or blisters which split open and caused active corrosion and pitting. I noticed in every case where a water inhibitive pigment was used that a perfect condition of the film was shown after an exposure of twenty months. **Mr. Gardner.**

REPORT OF COMMITTEE D-1 ON
PRESERVATIVE COATINGS FOR STRUCTURAL
MATERIALS.

In accordance with the policy stated in last year's report, the work that has been accomplished since that time will be presented in detail by the chairmen of the various sub-committees.

The report of Sub-Committee B, appointed to inspect the paint test on the Pennsylvania Railroad bridge over the Susquehanna River at Havre de Grace, contains an averaged statement of the condition of the paint on the panels and bridge. It was the intention to include photographs of these panels to show the condition of the metal under the paint after six years' exposure, but the photographs made do not show this point clearly. If possible another series of photographs will be made, as it is desired that a permanent record of the condition of these panels shall be obtained.

It was not possible for Sub-Committee D, appointed to cooperate with a sub-committee of Committee A-5, to inspect the steel plates at Atlantic City in time to present their report at this meeting, but the inspection has been made and the result will appear in the Proceedings for this year.*

Sub-Committee E on Linseed Oil has continued the investigation reported in the Proceedings of the Society in 1909. The analyses of four samples of oil obtained at that time and held sealed in air-tight containers have been repeated, and twelve additional samples representing the products crushed from last year's crop have also been examined. The re-tests of the original samples indicate that no appreciable change has occurred after nearly two years' storage. The analyses were made in seven different laboratories and all results carefully checked, so it is believed that the average of these results taken with the results previously reported can be considered as furnishing correct constants for raw linseed oil made from domestic seed. The report includes a carefully conducted investigation by the Bureau of Standards on these oils to determine the coefficient of expansion of linseed oil between

* See pp. 192-194.—ED.

the temperatures of 4° and 40° C. This determination will be of much value in correcting the specific gravity of linseed oils for variation in temperature.

Sub-Committee F, appointed to frame definitions of terms used in paint specifications, has defined certain of the terms used and presents them in a tentative form subject to further revision and modification.

Sub-Committee J on the Testing of White Paints has developed the details of a comprehensive exposure test of white pigments. Some 120 pigment formulas have been designed from 13 single pigments in primary, binary, ternary, and quaternary combinations with a standard oil and drier, so as to show, if possible, the effect of the progressive increase in these pigments. The plan includes the details of a method to determine and obtain a uniform consistency of the paints and a design for the panels and fence for exposing them.

The pigments and oil for this test have been donated by paint manufacturers. The grinding and mixing of the paints and the preparation of the drier has been undertaken by Professor Allen Rogers of Pratt Institute of Brooklyn. The Pennsylvania Railroad Company will prepare the panels, and the Baltimore and Ohio Railroad Company will apply the paints. It is expected that the Departments of Agriculture and of Commerce and Labor will provide for the exposure of these panels at the experimental farm near Arlington, Va. It is believed that the details of the test have been so determined and specified that the final result will add materially to the general knowledge on this problem.

Sub-Committee C on Paint Vehicles* has made a promising start in this investigation. The program as planned includes laboratory tests on the time of drying and the physical character of films of various drying, semi-drying, and non-drying oils to which fixed and varying amounts of a standard and different types of driers have been added. These tests are to be applied to the oils and driers with and without pigments. In addition to these laboratory tests, exposure tests are to be made under service conditions, using a standard pigment but varying the vehicle as outlined above.

*The Sub-Committee on Paint Vehicles was appointed during the past year, and was given the designation "C", after the discharge of former Sub-Committee C on Inspection of the Wooden Panels at Atlantic City on completion of its work in 1910.

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The Committee has had this investigation in mind ever since its organization, as it is believed that the vehicle is fully as important as the pigment in this type of protective coatings, but it was necessary to test out one set of variables at a time. The investigation on pigments seems to have progressed far enough, however, to warrant at least a start on this coordinate branch of the subject.

The investigations of the other sub-committees have been continued during the past year.

Respectfully submitted on behalf of the Committee,

S. S. VOORHEES,
Chairman.

G. W. THOMPSON,
Secretary.

REPORT OF SUB-COMMITTEE B ON INSPECTION OF THE HAVRE DE GRACE BRIDGE.

The 1911 spring inspection of the Havre de Grace Bridge was called for April 21 and 22, under the following program: The first day to be devoted to an examination of the plate panels, when it was to be determined which of these were to be removed for photographing before and after the removal of the coatings; the second day to be devoted to a thorough inspection of the bridge proper. Rain prevented the carrying out of the second day's program as *originally* planned. The schedules of plate examinations are as follows:

- A.....Chalking.
- B.....Checking, cracking, alligating, etc.
- C.....General surface conditions.

with the following marking for each:

Excellent.....	10 to 8
Good.....	8 to 6
Fair.....	6 to 4
Poor.....	4 to 2
Failure.....	2 to 0

The results of the panel inspection of April 21 are given in the accompanying Table of Individual Ratings, which contains the averages of all nine panels, covering three rates of application.

It is of record that the examinations oftentimes showed marked variation in the condition of the protective coverings under the different rates of application, and it may be assumed that this clearly proves that each paint has what may be styled its "natural covering rate," and that the panel rate approximating thereto generally showed the best. This rate in the majority of cases was 600 sq. ft. per gallon.

REVIEW.

Under A (chalking), the average rating of 14 paints was 8.7, fairly excellent; of 4 paints 7.4, fairly good; of 1 paint 4.5, only fair.

ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. 177

TABLE OF INDIVIDUAL RATINGS.

* Paint.	Examined for	Alten.	McNaughton.	Sabin.	Chapman.	Polk.	Gibboney.	Average, 1911.	Remarks.	Average, 1910.
1	A	8.0	7.0	9.0	8.0	10.0	7.0	8.0	Very good	8.4
	B	10.0	10.0	10.0	9.5	10.0	10.0	10.0	Excellent	10.0
	C	7.0	7.0	8.7	9.0	4.0	6.4	7.0	Good	6.6
2	A	8.0	10.0	9.0	7.0	8.5	6.6	8.2	Very good	8.6
	B	6.0	6.0	8.3	4.0	6.1	8.7	6.5	Fairly good	8.2
	C	6.5	4.7	5.0	8.0	5.0	6.0	5.7	Fair	5.3
3	A	8.0	8.0	8.5	8.0	8.0	7.0	7.6	Quite good	7.9
	B	10.0	10.0	9.7	10.0	10.0	9.0	9.8	Excellent	10.0
	C	8.0	8.0	7.2	8.0	7.3	6.5	7.5	Quite good	7.6
4	A	8.0	10.0	9.5	8.0	9.0	8.8	8.9	Fairly excellent	7.8
	B	10.0	10.0	9.8	10.0	10.0	8.8	9.8	Excellent	9.8
	C	7.0	8.7	6.8	8.0	7.7	7.4	7.6	Quite good	8.8
5	A	9.0	10.0	9.5	5.0	8.5	9.0	8.5	Fairly excellent	9.6
	B	10.0	10.0	10.0	10.0	10.0	10.0	10.0	Excellent	10.0
	C	9.0	9.7	8.0	9.0	8.3	8.1	8.3	Very good	8.7
6	A	9.0	10.0	9.0	5.0	8.3	10.0	8.6	Fairly excellent	9.0
	B	10.0	10.0	10.0	10.0	10.0	10.0	10.0	Excellent	10.0
	C	9.0	10.0	8.5	9.5	8.8	9.0	9.1	Fairly excellent	9.0
7	A	8.0	10.0	8.0	7.0	8.2	7.9	8.2	Very good	8.8
	B	10.0	10.0	10.0	10.0	10.0	8.7	9.8	Excellent	10.0
	C	8.0	9.0	7.7	8.0	7.0	7.8	7.9	Very good	8.7
8	A	9.0	10.0	9.0	8.0	9.0	9.8	9.1	Fairly excellent	9.2
	B	10.0	10.0	10.0	10.0	10.0	9.0	9.8	Excellent	10.0
	C	8.0	9.0	7.5	8.0	7.6	8.0	8.0	Very good	9.0
9	A	8.0	8.0	9.0	5.0	7.5	9.0	7.8	Very good	9.2
	B	10.0	10.0	10.0	10.0	10.0	9.0	9.8	Excellent	10.0
	C	8.8	8.8	7.0	8.0	7.0	8.3	7.9	Very good	8.6
10	A	8.0	6.0	8.5	7.0	7.6	7.0	7.3	Good	8.4
	B	6.0	7.0	8.0	6.0	6.8	7.0	6.8	Fairly good	8.0
	C	10.0	10.0	9.0	6.0	8.6	10.0	8.9	Very good	9.2
11	A	7.0	6.0	8.5	6.0	7.0	8.0	7.1	Good	8.2
	B	9.0	8.0	9.7	7.0	8.4	7.3	8.3	Very good	8.4
	C	10.0	10.0	9.0	5.0	8.3	9.8	8.7	Very good	8.8
12	A	9.0	10.0	9.5	9.0	9.4	9.0	9.3	Fairly excellent	9.2
	B	10.0	10.0	10.0	10.0	10.0	9.0	9.8	Excellent	10.0
	C	9.0	10.0	8.3	9.0	7.3	8.8	8.7	Very good	9.4
13	A	10.0	10.0	10.0	9.0	9.7	7.9	9.4	Fairly excellent	9.0
	B	10.0	10.0	10.0	10.0	10.0	8.9	9.8	Excellent	10.0
	C	8.0	7.7	7.0	8.0	7.3	7.2	7.5	Quite good	8.1
14	A	9.0	10.0	9.0	8.0	9.0	9.0	9.0	Fairly excellent	8.8
	B	10.0	10.0	10.0	10.0	10.0	9.0	9.8	Excellent	9.8
	C	8.0	10.0	9.0	8.5	7.3	9.8	8.8	Very good	8.6
15	A	3.0	5.0	7.0	6.0	3.8	2.0	4.5	Barely fair	3.6
	B	2.0	0.0	5.0	2.0	2.2	1.8	2.2	Failed	3.5
	C	2.0	2.0	3.5	5.0	0.0	1.3	2.3	Failed	3.6
16	A	9.0	10.0	9.0	8.0	9.0	9.0	9.0	Fairly excellent	9.0
	B	10.0	10.0	10.0	10.0	10.0	9.8	10.0	Excellent	10.0
	C	8.0	8.0	8.8	8.0	8.5	9.1	8.4	Fairly excellent	9.2
17	A	9.0	10.0	8.5	8.0	8.9	8.8	8.9	Fairly excellent	9.2
	B	10.0	10.0	9.7	10.0	9.9	9.0	9.8	Excellent	8.8
	C	8.0	7.3	7.8	7.0	8.6	6.9	7.6	Good	7.9
18	A	9.0	10.0	9.0	8.0	9.0	8.8	9.0	Fairly excellent	9.4
	B	10.0	10.0	10.0	10.0	10.0	9.0	9.8	Excellent	9.9
	C	9.0	8.0	9.0	8.5	8.6	9.1	8.7	Very good	9.2
19	A	8.0	10.0	8.5	8.0	8.8	8.0	8.6	Very good	9.2
	B	10.0	9.0	10.0	8.0	9.7	9.0	9.6	Excellent	9.3
	C	8.0	6.0	7.5	8.0	8.0	6.2	7.3	Good	8.8

* The compositions of these paints are given in the *Proceedings*, Vol. VIII, 1908, pp. 173-178.

Under B (checking, etc.), the average rating of 16 paints was 9.7, nearly excellent; of 2 paints 6.6, more than fair; of 1 paint 2.2, failed.

Under C (general conditions), the average rating of 9 paints was 8.6, very good; of 8 paints 7.5, nearly good; of 1 paint 5.7, very fair; of 1 paint 2.3, failed.

For comparison the average results under the same scale of rating for the 1910 report are listed. Only two of the individual inspectors this year are the same as last year, so that additional interest is given to this comparison of averages. The results generally show intelligent differentiation, with some deterioration in the majority of cases. It is to be noted that one individual report, that of Mr. Chapman, a member of Committee D-1, though not of the actual official sub-committee of inspection, shows wider variation in marking, due very probably to the fact that this was his first official examination and naturally he was not as conversant with the scale used as the other members of the party.

It was determined to remove the average "general condition" plate of the three panels at the 900 sq. ft. per gallon rate, for each paint, for photographic examination. This was done under the supervision of the Chairman of the Inspection Committee on May 2, at which time a thorough inspection of the bridge proper was made by Mr. W. A. Aiken, assisted by Mr. Anderson Polk. The panels were carefully packed and have been shipped to New York.

The inspection of the bridge proper, referred to above, resulted in the following general conclusions in practical agreement with that reported last year as the average of several individual conclusions, though from a much less detailed inspection of the bridge proper at that time. It is undoubtedly a fact that generally the bridge structure is to-day in as good, and in the majority of cases better condition than similar panels. While there may be shades of difference in the protection afforded, it would be difficult to draw these sharply at this time except in the cases mentioned below.

Paint 1, while meeting very fully the tests for chalking, cracking, etc., is of markedly poor character, in some respects more pronounced than any. What protection is being afforded—and this is better than on the panels, which average only good—is being furnished by the under-coat.

Paint 2 is furnishing much better protection on the structure than on the panels, contrary to the previous indications of early disintegration as originally reported in 1908. This is undoubtedly due to the fact that the superintendent of tests, in his original report at the time of undertaking these investigations, marked the natural spreading rate of this paint to be 600 sq. ft. per gallon, and it is this rate which shows best in the panels, although it is not as good as on the bridge proper.

Paint 4 is exceptional in not furnishing as good protection to the bridge proper as to the panels.

Paint 10 shows better protection on the bridge proper than on the panels, even though these latter are rated very good. The paint, however, shows a marked tendency to decay and is likely to fail in the near future.

Paint 14, on the bridge proper, while showing minute cracking of the outer coat, as noted three years ago, disclosing the undercoat of red lead prominently throughout the structure, indicates failure to be superficial, more apparent than real, and to-day affords good protection, better in fact than in many of the paints which lack any evidence of cracking, checking or alligating.

Paint 15, on the bridge proper, except in numerous well-defined areas showing very badly throughout, is in better general condition than on the panels, which are all in very poor condition and are marked as having failed. The panels as a whole are typical in their condition of the well-defined areas referred to above, scattered throughout the structure proper.

With the above special exceptions, all paints are affording excellent protection on the bridge proper. It was noted that generally on the horizontal struts and laterals and their connections, affording the easier accumulation of moisture, most of the paints show more or less deterioration. This only emphasizes the necessity for special care in painting structures. The light latticing of the main riveted members shows this tendency more or less in the majority of cases, most markedly on the up-stream side of the structure.

The photographing of the typical plates was begun in Brooklyn, N. Y., on May 25, in the presence of the Chairman and Mr. A. H. Sabin. The removal of the coatings was subsequently accomplished. In all cases the condition of the plate material

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was found to fully corroborate the ratings given the several paints,
as generally at this date affording excellent protection.

Respectfully submitted on behalf of the Sub-Committee,

W. A. AIKEN,
Chairman, Sub-Committee B.

REPORT OF SUB-COMMITTEE C ON PAINT VEHICLES.

At the January meeting of Committee D-1 a sub-committee consisting of the following members was appointed to investigate paint vehicles:

G. B. Heckel,
Glenn H. Pickard,
Allen Rogers,
A. H. Sabin,
H. A. Gardner, *Chairman*.

At a subsequent meeting of the sub-committee it was determined to start the investigations with a series of tests on certain drying, semi-drying, and non-drying oils, determining their drying values and rate of oxygen absorption, etc., when spread out in thin films. A quantity of the following oils was selected for the tests and subsequently secured from sources known to be reliable:

Lead and manganese linoleate drier.*
Boiled linseed oil (resinate type).
Boiled linseed oil (linoleate type).
Lithographic linseed oil.
Blown linseed oil (containing drier while being blown).
Heavy mineral oil.
Soya bean oil.
Rosin oil.
Cottonseed oil.
Corn oil.
Sunflower oil.
Menhaden oil.
Chinese wood oil, raw.
Chinese wood oil, treated.
Perilla oil.†
Lumbang oil.†
Dry rosin 20 per cent., boiled in 80 per cent. linseed oil.

* The drier used, upon analysis, showed the presence of 4.36 per cent. PbO and 2.51 per cent. MnO₂.

† The lumbang and perilla oils were imported and arrived subsequent to the starting of the tests. They were therefore not included in the tests.

Four-ounce sample bottles of each oil were sent to the Committee members, with the request to proceed with the tests along the lines agreed upon at the Committee meeting. The instructions for making these tests are outlined as follows:

(a) A series of small glass plates, approximately 5 by 7 ins., are to be prepared by each member of the Committee. These plates are to be thoroughly cleaned, carefully numbered, and weighed upon a chemical balance. The oils to be used for the tests are to be numbered corresponding to the plates. A test of each oil is to be made by painting it upon the surface of a glass plate with a camel's hair brush, subsequently weighing the plate and the oil. These tests are to be exposed under constant conditions of temperature, if possible, for three weeks' time, making weighings of each plate every day for six days and then every other day for twelve days.

(b) Another series of tests shall be made, in which 80 per cent. of raw linseed oil is to be combined with each of the above-named oils. Previous to making any of the tests, *there should be added to each oil or to each combination, 5 per cent. of a drier containing lead and manganese.* The drier to be used is of the standard grade submitted together with the oil samples. The results of the tests showing the increase by oxygen absorption, etc., are to be charted and submitted at the end of the tests, so that they may be compared with the results obtained by each member of the Committee.

(c) If possible, the oils and mixtures of oils used in the above tests are to be ground with pure silica and painted out upon sized paper, three-coat work, the films to be stripped and tested for strength upon a paint filmometer, at two periods two months apart.

The drying of oils to a firm surface when spread in a thin layer is accompanied by an increase in weight, due to oxidation, etc. The percentage of oxygen absorbed often affords a criterion of the drying of the oil under examination, and this factor, together with data regarding the appearance of the oil film, should be taken into consideration when judging the value of an oil or oil mixture. Conditions of light, air, temperature, etc., often cause great variations in the drying of oils and the percentage of oxygen absorbed, etc., as shown by the results obtained in the following tests. Although it was impossible in these tests to have the conditions under which each experimenter worked parallel in nature, the tests afford nevertheless considerable information for guiding future work of a similar nature.

An examination of the results obtained, which are given in Tables I to XV, following this report (pages 184-191), showed

generally that the greatest increase in weight occurred during the period in which the oil dried to a firm film. This occurred in most cases within 48 hours. After this period, a slight increase in weight was often noticed and then a more or less steady decline, varying with the oil examined. Had the oil tests been continued for a greater length of time, a much greater loss might have been observed.

It was impossible to include in the tests the oil-silica film work, on account of lack of time. It is believed, however, that these tests should be conducted, as they would throw much light on the elasticity and strength given to paint films by various oils.

Respectfully submitted on behalf of the Sub-Committee,

H. A. GARDNER,
Chairman, Sub-Committee C.

TABLE I.—(a) BOILED LINSEED OIL (RESINATE TYPE), 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																		Remarks.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		19
Gardner.	0.1997	11.9	12.5	12.7	13.1	12.8	12.7	.....	12.7	.....	12.6	.....	12.8	.....	12.8	.....	12.7	.....	12.9	.....	{ Dried to firm, smooth film in 2 days.
Sabin.	0.6242	14.42	13.37	12.53	11.79	11.03	.....	10.17	10.34	10.12	10.09	.....	9.69	.....	9.04	.....	8.68	.....	8.13	.....	{ Tacky at end of 1st day. Nearly dry, end of 2d day. Perfectly dry, end of 10th day.
Pickard.	0.5027	10.21	10.00	9.57	9.65	8.99	.....	8.57	.....	8.93	.....	8.81	.....	9.31	.....	9.43	.....	9.11	.....	.....
Rogers. North..}	0.6024	13.69	13.01	12.50	12.29	12.00	12.25	.....	11.64	.....	10.73	.....	10.68	.....	11.18	.....	10.68	.....	.....	.....

(b) BOILED LINSEED OIL (RESINATE TYPE), 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1933	13.6	14.7	14.9	14.9	14.8	14.8	.....	14.8	.....	14.8	.....	14.7	.....	14.5	.....	14.7	.....	14.7	.....
Sabin.	0.3860	0.57	1.68	10.50	13.30	.....	12.51	.....	11.40	.....	10.20	.....	.....	.....	9.84	.....	8.54	.....	8.51	.....
Pickard.	0.4640	12.48	11.92	11.49	11.10	10.84	.....	9.48	.....	7.41	.....	7.56	.....	8.36	.....	8.54	.....	8.51	.....	.....
Rogers. North..}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE II.—(a) BOILED LINSEED OIL (LINOLEATE TYPE), 100 PER CENT.

Gardner.	0.1226	10.9	12.2	12.7	12.5	12.8	12.2	.....	12.2	.....	12.4	.....	12.1	.....	12.1	.....	12.1	.....	12.1	.....
Sabin.	0.5384	14.34	13.26	12.18	11.20	10.75	.....	9.88	10.25	10.01	9.91	.....	9.00	.....	9.12	.....	8.37	.....	8.30	.....
Pickard.	0.5696	10.25	10.41	10.22	10.16	9.90	.....	9.60	.....	9.72	.....	9.48	.....	9.97	.....	10.30	.....	9.59	.....	.....
Rogers. North..}	0.3306	12.09	11.33	10.94	11.10	10.86	11.25	.....	10.87	.....	9.72	.....	10.02	.....	10.62	.....	10.46	.....	.....	.....

(b) BOILED LINSEED OIL (LINOLEATE TYPE), 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1843	11.8	13.9	15.1	15.2	15.0	14.6	.....	14.6	.....	14.5	.....	14.4	.....	14.4	.....	14.6	.....	14.7	.....
Sabin.	0.5790	10.14	15.71	13.29	12.12	11.43	.....	10.05	10.26	9.55	9.32	.....	8.84	.....	8.46	.....	8.46	.....	7.68	.....
Pickard.	0.4653	12.40	11.90	11.50	11.11	10.90	.....	9.37	.....	8.53	.....	7.48	.....	8.43	.....	8.02	.....	7.27	.....	.....
Rogers. North..}	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE III.—(a) LITHOGRAPHIC LINSEED OIL, 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																			Remarks.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Gardner.	0.4011	6.9	8.5	8.9	8.9	8.7	8.6		8.6		8.6		8.6		8.4		8.4		8.3		{ Dried to glossy, firm film, slightly crinkled, in 2 days. Oil made very thick film on account of heavy body.
Sabin..	0.8733	0.87	3.85	5.14	6.07	6.40		6.84	7.22	7.36	7.57		7.75				7.98		7.83			7.80
Pickard..	0.8812	3.60	5.19	5.99	6.78	6.97		7.38		7.42		7.44		8.01		8.03				7.99	{ Remained sticky to 10 days, and even at end of 38 days was slightly tacky.
Rogers. } North.. }	2.7318	0.051	0.051	0.051	0.041	0.081	0.169		0.19		0.752		1.184		1.641		2.00				

(b) LITHOGRAPHIC LINSEED OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1300	10.2	11.3	11.9	12.0	11.8	11.8		11.8		11.8		11.6		11.8		11.9		11.9		{ Dried to firm, glossy film in 2 days.
Sabin...	0.7750	11.35	11.48	10.93	10.77	10.25		9.51	9.93	9.80	9.68		9.65				9.51		9.07		
Pickard..	0.6538	9.94	10.41	10.39	10.35	9.93		9.54		9.36		8.99		9.61		9.70				9.13	{ Ropiness of oil made very thick film, but dried in less than 2 days to smooth film. Films exhibited ridges.
Rogers. }																					
North.. }																					{ Formed skin, and 1st day. Slightly tacky, end 2d day, dry, but curled, end 10th day.

TABLE IV.—(a) BLOWN LINSEED OIL, 100 PER CENT.

Gardner.	0.2105	8.5	0.2	10.2	10.2	10.0	9.9		9.8		9.8		9.7		9.8		9.8		9.9		{ Ropiness of oil made very thick film, but dried in less than 2 days to smooth film. Films exhibited ridges.
Sabin...	0.8304	9.30	8.97	5.30	9.30	8.99		8.49	8.89	8.73	8.89		8.73				8.52		7.74		
Pickard..	0.8457	5.07	6.16	6.43	6.94	6.73		6.99		6.89		7.11		7.60		7.95				7.86	{ Formed skin, and 1st day. Slightly tacky, end 2d day, dry, but curled, end 10th day.
Rogers. }	1.0398	4.41	4.91	5.22	5.62	5.73	6.06		6.43		6.18		6.51		6.95		7.00				
North.. }																					{ Dried up to very glossy film in 2 days. Glass broke.

(b) BLOWN LINSEED OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.0774	10.4	12.8	13.1	12.9	12.1	11.9		12.0		11.8		11.7		11.6		11.6		11.8		{ Dried up to very glossy film in 2 days. Glass broke.
Sabin...	0.5329	11.82	12.76	10.98	10.39	9.81		8.69	9.15	8.91	8.97		8.67				8.22		7.63		
Pickard..	0.6218	10.71																		7.32	{ Dried up to very glossy film in 2 days. Glass broke.
Rogers. }																					
North.. }																					{ Dried up to very glossy film in 2 days. Glass broke.

TABLE V.—(a) MINERAL OIL, 100 PER CENT.*

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																		Remarks.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Gardner.	0.1032	12.5 (—)	14.2 (—)	16.7 (—)	19.4 (—)	19.4 (—)	19.5 (—)	19.5 (—)	19.5 (—)	19.5 (—)	19.5 (—)	19.3 (—)	19.4 (—)	19.4 (—)	19.4 (—)	19.5 (—)	19.5 (—)	19.5 (—)	19.5 (—)	Oil lost in weight throughout test on ac- count of presence of volatiles. No drying action observed. Film wet at end of test.
Sabin.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Broken before weigh- ings were made.
Pickard.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Remained oily dur- ing entire test.
Rogers North..	0.1075	8.12 (—)	16.22 (—)	21.22 (—)	25.58 (—)	28.41 (—)	28.92 (—)	35.25 (—)	35.25 (—)	35.76 (—)	43.96 (—)	43.96 (—)	45.28 (—)	45.28 (—)	45.28 (—)	45.28 (—)	48.08 (—)	48.08 (—)	48.08 (—)	

* Lost in weight throughout test.

(b) MINERAL OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Observer.	Wt. of Oil for Test, grams.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Remarks.
Gardner.	0.1884	6.4 (—)	6.8 (—)	7.2 (—)	7.8 (—)	8.1 (—)	7.9 (—)	7.9 (—)	7.9 (—)	7.9 (—)	8.1 (—)	8.1 (—)	7.8 (—)	7.8 (—)	7.8 (—)	7.8 (—)	7.8 (—)	7.8 (—)	7.8 (—)	7.8 (—)	Fair drying observed end of 2d day. Film tacky until end 8th day; after that, fairly firm film shown.
Sabin.	0.5663	11.51 (—)	8.21 (—)	6.51 (—)	5.19 (—)	4.36 (—)	2.72 (—)	3.12 (—)	2.82 (—)	2.59 (—)	2.59 (—)	2.35 (—)	2.35 (—)	2.35 (—)	2.35 (—)	1.36 (—)	1.36 (—)	0.53 (—)	0.53 (—)	0.14 (—)	
Pickard.	0.4050	9.66 (—)	8.92 (—)	6.82 (—)	6.03 (—)	4.68 (—)	2.64 (—)	2.64 (—)	0.30 (—)	0.30 (—)	0.56 (—)	0.56 (—)	0.04 (—)	0.04 (—)	0.14 (—)	0.14 (—)	0.14 (—)	0.14 (—)	0.86 (—)	0.86 (—)	
Rogers North..	0.2598	6.69 (—)	5.06 (—)	2.88 (—)	1.52 (—)	1.29 (—)	1.68 (—)	2.07 (—)	2.07 (—)	0.08 (—)	0.08 (—)	0.08 (—)	0.03 (—)	0.03 (—)	0.54 (—)	0.54 (—)	0.54 (—)	0.54 (—)	0.54 (—)	0.54 (—)	Sticky, end of 1st day; tacky, end of 2d day and end of 38 days.

TABLE VI.—(a) SOYA BEAN OIL, 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in -- Days.																		Remarks.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		19
Gardner.	0.1377	7.5	8.4	9.5	12.8	12.9	12.7		12.6		12.5		12.4		12.3		12.3		12.3		{ Film tacky until 2d day. Clear and fairly firm after 4th day.
Sabin...	0.3972	9.79	9.69	8.56	7.60	7.09		6.00	6.22	6.00	5.54		5.36			4.73		4.23		3.70	{ Sticky, end of 1st day; tacky, end of 2d day; slightly tacky, end of 10th and 38th days.
Pickard..	0.4366	9.87	9.87	9.33	8.66	8.13		6.44		4.88		4.26		4.99		4.04		4.23		4.94	
Rogers. }	0.3664	8.25	7.58	7.02	6.74	6.46	6.74		6.46		5.40		5.59		5.80		5.67				
North.. }																					

(b) SOYA BEAN OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.2218	11.5	11.8	12.5	13.9	14.0	14.0	.....	14.1	.....	14.1	.....	13.8	.....	13.6	.....	13.6	.....	13.6	.....	Clear, firm film observed at end of 2d day.
Sabin.	0.2877	12.78	12.78	11.74	11.23	10.60	.....	9.35	10.08	9.76	9.59	.....	9.59	.....	.....	.....	9.00	.....	8.09	.....	Tacky at end of 1st and 2d days. Dry, end 10th day.
Pickard.	0.4581	13.16	12.64	11.84	11.50	11.01	.....	9.15	.....	7.29	.....	6.61	.....	7.43	.....	6.96	.....	.....	.....	.....	.....
Rogers.	0.2249	11.74	12.27	10.38	9.43	9.66	9.75	.....	10.29	.....	9.08	.....	8.18	.....	8.95	.....	.....	.....	.....	.....	.....
North..																					.....

TABLE VII.—(a) ROSIN OIL, 100 PER CENT.

Gardner.	0.2690	1.5	1.5	1.8	3.0	5.2	4.9	.....	4.8	.....	4.8	.....	4.8	.....	4.8	.....	4.8	.....	4.8	.....	Tacky throughout test.
Sabin.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Too much on. Showed constantly increasing loss owing to fact that it did not dry, and ran off glass.
Pickard.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Only on 1st and 2d days. Tacky, end of 10th and 38th days.
Rogers.	0.4322	2.24	2.53	2.32	1.27	1.06	0.60	.....	0.24	.....	0.78	.....	0.68	.....	0.41	.....	0.39	.....	.....	.....	.....
North..																					.....

(b) ROSIN OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1686	7.4	7.8	8.5	8.5	8.4	8.1	.....	8.0	.....	8.0	.....	8.0	.....	7.9	.....	7.9	.....	8.2	.....	Film dried up nicely during 3d day, but remained slightly soft.
Sabin.	0.7105	6.64	6.40	6.05	5.63	5.23	.....	4.42	4.92	4.83	4.57	.....	4.68	.....	4.13	.....	4.13	.....	3.81	.....	.....
Pickard.	0.4016	12.2	11.45	11.13	10.53	10.13	.....	8.81	.....	8.12	.....	7.45	.....	8.27	.....	8.52	.....	8.52	.....	8.02	.....
Rogers.	0.3263	11.48	12.02	10.60	10.26	10.42	10.42	.....	10.05	.....	9.96	.....	9.52	.....	9.96	.....	.....	.....	.....	.....	.....
North..																					.....

TABLE VIII.—(a) COTTON SEED OIL, 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																		Remarks.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		19
Gardner.	0.2026	4.5	4.8	4.8	5.1	8.6	8.7		8.1		7.9		8.0		8.0		8.1		8.0	
Sabin.	0.7247	8.03	7.48	6.68	6.00	5.05		4.85	5.09	4.95	4.80									
Pickard.	0.4135	7.04	7.16	6.62	6.24	5.78		3.72		2.08		1.72		2.52		2.35		2.32		
Rogers.	0.3553	6.67	5.61	4.85	4.65	4.37	4.71		4.57		2.97		3.11		3.39		3.39			
North.																				

(b) COTTON SEED OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1516	8.5	8.7	9.1	10.8	11.9	11.8		11.9		11.9		11.8		11.8		11.8		10.7	
Sabin...	0.9468	11.00	11.15	10.58	10.17	9.82		9.02	9.42	9.35	9.27		9.32		9.29		8.81		8.24	7.92
Pickard...	0.6160	10.94	10.81	10.51	10.37	9.87		8.93		8.90		8.70		9.29		9.63		9.63		8.47
Rogers. North...	0.2553	11.83	11.83	10.15	9.29	9.29	9.45		10.00		8.95		8.06		8.61					

TABLE IX.—(c) CORN OIL, 100 PER CENT.

Gardner.	0.0574	1.9	4.2	4.6	4.8	7.5	7.1		7.1		7.1		7.2		7.1		7.0		6.9	
Sabin...	0.5858	0.22	7.03	8.79	7.43	7.17		5.85	6.02	5.84	5.58		5.38				4.78		4.15	3.63
Pickard...	0.4951	1.22	5.86	7.27	11.35	11.35		11.37		6.26		4.97		5.62		5.34			5.34	
Rogers. North...	0.3300	4.63	7.27	7.14	6.96	6.69	6.93		6.84		5.11		5.17		5.38		5.17			

(b) CORN OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1664	7.5	8.4	8.6	10.2	10.4	10.6		10.5		10.3		10.3		10.3		10.2		10.0	
Sabin...	0.5469	13.01	12.41		11.13	11.52		11.22	10.98	10.38	9.64		9.07				8.38		8.77	
Pickard...	0.3716	13.81	12.92	12.16	11.71	11.11		9.23		8.29		7.24		8.42		8.26			7.94	
Rogers. North...	0.1711	11.87	11.69	9.78	8.33	8.50	8.62		9.61		8.16		7.00		8.23					

TABLE X.—(a) SUNFLOWER OIL, 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																			Remarks.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Gardner.	0.1414	6.3	8.2	11.5	11.6	11.5	11.5	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.2	11.2	11.0	11.0	Film fairly firm, end of 3d day.	
Sabin.	0.6292	9.69	9.42	7.99	7.43	7.04	6.12	6.45	6.12	5.92	5.92	5.69	5.69	5.69	5.24	5.24	4.57	4.57	4.20	4.20	
Pickard.	0.5837	7.85	7.73	7.45	7.02	6.36	5.16	4.57	4.57	4.57	4.20	4.20	4.54	4.54	4.61	4.61	4.30	4.30	4.30		
Rogers.	0.2540	8.39	6.94	6.21	6.13	5.81	6.01	6.09	6.09	4.81	4.81	4.73	4.73	4.81	4.81	5.01	5.01	5.01	5.01	Sticky, end 1st day; tacky, end 2d day; slightly tacky, end 10th day.	
North..																					

(b) SUNFLOWER OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1600	9.5	11.0	11.1	11.3	11.4	10.9	10.8	10.8	10.8	10.8	10.8	10.8	10.6	10.6	10.6	10.6	10.6	10.9	10.9	Good firm glossy film shown at end of 2d day.
Sabin.	0.5030	14.21	14.21	12.66	14.01	11.59	10.24	10.63	10.34	10.34	10.34	10.27	10.27	6.22	6.22	11.33	10.73	10.73	10.30	10.30	
Pickard.	0.4470	12.62	12.02	11.43	11.65	10.25	8.14	6.26	6.26	6.26	5.64	5.64	5.64	5.64	5.64	5.62	5.62	5.35	5.35	5.35	
Rogers.	0.2261	11.54	11.85	9.92	9.13	8.95	9.04	9.52	9.52	8.55	8.55	7.67	7.67	8.20	8.20	8.20	8.20	8.20	8.20	8.20	Dry on 1st, 2d and 10th days.

TABLE XI.—(a) MENHADEN OIL, 100 PER CENT.

Gardner.	0.1944	7.7	8.1	8.9	10.1	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.6	9.6	9.6	9.6	9.6	9.6	Good drying during 2d day. Fairly firm film.
Sabin.	0.5292	12.47	12.17	11.70	11.47	11.13	10.28	11.20	11.15	11.02	11.02	11.37	11.37	8.91	8.91	10.85	10.34	10.34	9.90	9.90	
Pickard.	0.7005	10.79	10.98	10.83	10.96	10.57	9.27	8.48	8.48	8.27	8.27	8.27	8.27	8.91	8.91	8.75	8.75	8.21	8.21	8.21	
Rogers.	0.3150	11.27	10.16	9.72	9.97	9.94	10.27	10.36	10.36	8.80	8.80	9.22	9.22	9.40	9.40	9.31	9.31	9.31	9.31	9.31	Sticky, end 1st day; Slightly tacky, end 2d and 10th days.

(b) MENHADEN OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.2448	8.5	10.4	12.2	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.9	12.8	12.8	12.7	12.7	12.9	12.9	12.9	Good firm elastic film shown after 2d day.
Sabin.	0.4959	14.11	13.47	12.63	12.04	11.69	10.44	11.09	11.04	10.74	10.74	10.90	10.90	8.33	8.33	10.18	9.48	9.48	8.93	8.93	
Pickard.	0.4201	13.19	12.88	12.23	11.81	11.17	9.50	8.48	8.48	7.77	7.77	7.77	7.77	8.33	8.33	8.24	8.24	8.12	8.12	8.12	
Rogers.	0.2456	10.99	11.28	9.56	8.90	8.73	8.72	9.34	9.34	8.40	8.40	7.37	7.37	8.11	8.11	8.11	8.11	8.11	8.11	8.11	Nearly dry on 1st and 2d days.

TABLE XII.—(a) CHINESE WOOD OIL (RAW), 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																			Remarks.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Gardner.	0.2266	4.1	11.2	14.9	14.4	14.4	14.2		14.2		14.2		14.2		14.2		14.2		14.5		{ Film crystallized and remained soft until 3d day. Hard but opaque film shown after 4th day.
Sabin.	0.5545	0.0	0.0	11.02	11.53	11.03			10.53	10.74	10.47	10.27	10.22			9.80		9.25		8.86	
Pickard.	0.4933	0.59	2.09	5.13	7.56	8.68			10.11	9.65			9.77			9.73				9.33	
Rogers. North..	0.4036	0.54	2.80	5.10	6.00	6.27	7.09		8.39		8.01		8.55		9.13		9.27				

Sticky, end of 1st and 2d days; dry but drawn, end of 10th day.

(b) CHINESE WOOD OIL (RAW), 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.2087	9.0	12.1	12.9	12.8	12.8	12.7		12.6		12.6		12.6		12.5		12.5		12.7		Clear firm film shown after 3d day.
Sabin.	0.2967	14.46	13.11	11.72	10.68	9.77			8.66	8.80	8.90	8.49	8.15			8.05		7.41		7.04	
Pickard.	0.3633	14.37	13.66	13.11	12.41	11.78			10.51		8.72		7.01		8.82		8.36		7.96		
Rogers. North..}	0.2285	11.99	11.90	10.14	9.30	9.08	9.30		9.70		8.90		7.34		7.78						

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TABLE XIII.—(a) CHINESE WOOD OIL (TREATED), 100 PER CENT.*

Gardner.	0.1678	38.0	30.0	28.0	28.0	28.0	28.2		28.0		27.5		26.0		26.0		26.0		26.2		Loss observed due to presence of volatiles. Firm, clear film shown at end of 1st day.
Sabin.	0.4159	19.06	20.16	20.47	20.47	20.80			21.09	20.87	20.98	20.78	20.70		20.97		21.22		21.11		
Pickard.	0.2934	0.92	0.41	0.72	0.79	0.13			0.22		0.46		0.44		0.43		0.42		0.43		
Rogers. North..}	0.3937	3.53	3.58	3.25	3.25	3.23	2.93		2.55		3.40		3.23		2.61		2.48				

* Lost in weight throughout test.

(b) CHINESE WOOD OIL (TREATED), 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1638	8.4	9.4	9.8	9.7	9.9	9.9		10.0		9.6		9.5		9.5		9.5		9.6		Clear hard film shown during 2d day.
Sabin.	0.6572	9.25	8.07	7.36	6.75	6.25			5.49	5.87	5.70	5.67	4.37		5.15		4.98		4.17		
Pickard.	0.4892	8.93	8.71	8.44	8.16	7.06			6.75		5.99		5.50		6.01				5.87		
Rogers. North..}	0.2644	3.21	3.48	2.15	1.58	1.50	1.77		2.30		1.62		0.86		1.50						

Dry at end of 1st day.

TABLE XIV.—(a) 20 PER CENT. DRY ROSIN IN 80 PER CENT. LINSEED OIL, 100 PER CENT.

Observer.	Wt. of Oil for Test, grams.	Percentage Increase in Weight, in — Days.																		Remarks.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		19
Gardner.	0.2030	12.0	14.1	14.8	14.2	14.5	14.0		14.1		14.1		14.0		14.0		14.0		14.1		{ Rapid drying ob- served. Hard film shown during 2d day.
Sabin.	0.5185	3.76	8.76	9.20	9.20	8.49		9.07		9.01		9.09		10.50		10.16					
Pickard.	0.2554	1.80	11.78	12.17	12.29	12.02	12.49		13.15		11.85		11.78		12.69		12.83				{ Oily end 1st and 2d days; slightly tacky, end 10th day.
Rogers.																					
North..																					

(b) 20 PER CENT. DRY ROSIN IN 80 PER CENT. LINSEED OIL, 20 PER CENT.; RAW LINSEED OIL, 80 PER CENT.

Gardner.	0.1500	10.9	13.5	13.6	13.0	13.0	13.0		13.1		13.1		13.0		12.9		13.0		13.2		{ Clear hard film after 2d day.
Sabin.	0.7105	14.19	13.17	11.84	11.46	10.87		9.80	10.33	10.40	10.04		10.35				9.64		8.98		
Pickard.	0.4568	12.86	12.73	12.13	12.02	11.30		10.95		11.21		10.53		11.21		10.88			11.43		{
Rogers.																					
North..																					

TABLE XV.—(a) RAW LINSEED OIL, 100 PER CENT.*

Sabin.	0.5274	0.26	0.51	0.11	2.35	9.14		14.48	14.48	14.18	13.86		13.00		12.23		11.66		11.07	
Pickard.	0.5326	12.42	12.39	11.88	11.83	11.08		10.29		9.56		9.85		10.30		10.12			10.78	

* The test of this oil was made without the addition of 5 per cent. of drier, the quantity used in all the other tests.

(b) DRIER, 100 PER CENT.†

Rogers.	0.3445	48.95	48.53	48.68	48.68	48.48	48.26		48.43		48.89		48.22		48.22						Dry at end of 1st day
North..		(—)	(—)	(—)	(—)	(—)	(—)		(—)		(—)		(—)		(—)						

† Lost in weight throughout test.

REPORT OF SUB-COMMITTEE D ON
THE ATLANTIC CITY STEEL PAINT TESTS.

On Wednesday, June 28, 1911, the second inspection of the Atlantic City Steel Test Panels erected in October, 1908, was made by the Sub-Committee, which had agreed to report upon the condition of the painted surfaces, leaving any report on the comparative corrosion of the various types of metal used in the test to Committee A-5 on the Corrosion of Iron and Steel.

Ratings were given each panel according to the amount of rust apparent on the painted surfaces of the panels, as well as the degree of checking, chalking, scaling, cracking, peeling, loss of color, and other signs of paint failure shown. The system of rating which took into consideration all of the above conditions, was similar to the system used at the first inspection during 1910, when 0 (zero) recorded the worst results and 10 (ten) the best results.

In Table I there is shown the rating accorded by each inspector to each panel, as well as an average for each panel.

In Table II there is shown the rating of those panels which were considered by the Sub-Committee as meriting from 8 to 10 and having given the best all-around service.

For full details of the tests as well as an outline of former reports, the reader is referred to the Report of the First Inspection, Report of Committee A-5, Proceedings, Vol. X, 1910, pp. 73 ff.

Respectfully submitted on behalf of the Sub-Committee,

H. A. GARDNER,
Chairman, Sub-Committee D.

ON PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS. 193

TABLE I.—SECOND INSPECTION OF PAINT-TEST STEEL PANELS,
ATLANTIC CITY, N. J.

BY SUB-COMMITTEE D OF COMMITTEE D-1.

Panel.	Pigment.	W. H. Walker	P. H. Walker	Gardner, Chairman.	Chapman	Average.
1	Dutch process white lead.....	2	3	3	5	3.7
2	Quick process white lead.....	4	4	3	6	4.2
3	Zinc oxide (xx).....	1	1.5	1	2.5	1.5
4	Sublimed white lead.....	9	9.5	9	8.5	9.0
5	Sublimed blue lead.....	9	9.5	9.5	7.5	8.8
6	Lithopone.....	2	1.5	2	3.5	2.2
7	Zinc white lead.....	3	4	5	7	4.7
9	Orange mineral (American).....	9	9	9	6.5	8.3
10	Red lead.....	9	9	9	6.5	8.3
12	Bright red oxide.....	8.5	9	8	7	8.1
14	Venetian red.....	7	9	7	9	8.0
15	Prince metallic brown.....	5	7.5	6	8	6.3
16	Natural graphite.....	6	8	4	9.5	6.8
17	Artificial graphite.....	5	7.5	4	7	5.9
19	Lamp black.....	5	7.5	5	8	6.3
20	Willow charcoal.....	9	8.5	9	9	8.8
21	Carbon black (gas).....	7	8.5	5	8.5	7.2
24	Yellow ochre (French).....	5	7	2	8	5.5
27	Barytes (natural).....	1	1	1	0	0.7
28	Barytes (precipitated).....	2	1.5	2	2	1.8
29	Calcium carbonate (whiting).....	0	0	0	0	0.0
30	Calcium carbonate (precipitated).....	0	0	0	0	0.0
31	Calcium sulphate (gypsum).....	1	1	2	3	1.7
32	China clay (kaolin).....	6	6	7	6.5	6.3
33	Abestine (magnesium silicate).....	5	4.5	6	5	5.1
34	American vermilion (chrome scarlet).....	10	10	10	10	10.0
36	Lead chromate.....	7	7.5	8.5	8	7.7
39	Zinc chromate.....	9	9.5	10	9.5	9.5
40	Zinc and barium chromate.....	9	9.5	10	9.5	9.5
41	Chrome green (blue tone).....	10	10	10	9.5	9.8
44	Prussian blue (W. S.).....	9	9.5	8.5	9	9.0
45	Prussian blue (W. I.).....	8	9.5	8	8.5	8.5
48	Ultramarine blue.....	0	0	0	0	0.0
49	Zinc and lead chromate.....	10	9.5	10	9.5	9.7
51	Magn tie black oxide.....	9	9.5	10	9.5	9.5
111	Brown (composite paint).....	7	9	9	9	8.5
222	Black (composite paint).....	9	9	9	8.5	8.8
333	White (composite paint).....	4	4	7	3	4.5
444	Green (composite paint).....	5	7	7	8	6.7
555	Black (composite paint).....	9	9	6	9	8.2
666	Brown (composite paint).....	8	8	6	9	7.7
777	White (composite paint).....	7	10	5	7	7.2
888	Green (composite paint).....	7	8	8	9	8.0
2000	1 coat zinc chromate, 1 coat iron oxide excluder.....	8	8.5	8	8	8.1
3000	1 coat lead chromate, 1 coat iron oxide excluder.....	7	8	7	7.5	7.3
4000	1 coat red lead, 1 coat iron oxide excluder	7	8.5	8	7.5	7.7
100	Straight carbon black paint with turps and drier.....	5	8.5	4	8.5	6.5
90	Straight lamp black paint with turps and drier.....	5	7	3	8	5.7
5555	Coal tar paint (over red lead).....	4	8	2	7	5.2
1000	Chrome resinat in oil, 1 coat.....	1	0	0	2	0.7
1 (plate)	Boiled (linseed) oil, 3 coats.....	1	0	1	4	1.5

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TABLE II.—ANALYSIS OF AVERAGES. GRADE OF EXCELLENCE FROM 8 TO 10.

Panel.	Pigment.	Average
34	American vermilion (chrome scarlet).....	10.0
41	Chrome green (blue tone).....	9.8
49	Zinc and lead chromate.....	9.7
39	Zinc chromate.....	9.5
40	Zinc and barium chromate.....	9.5
51	Magnetic black oxide.....	9.5
4	Sublimed white lead.....	9.0
44	Prussian blue (W. S.).....	9.0
5	Sublimed blue lead.....	8.8
20	Willow charcoal.....	8.8
222	Black (composite paint).....	8.8
45	Prussian blue (W. I.).....	8.5
111	Brown (composite paint).....	8.5
9	Orange mineral (American).....	8.3
10	Red lead.....	3.3
555	Black (composite paint).....	8.2
12	Bright red oxide.....	8.1
2000	{ 1 coat zinc chromate.....	8.1
	{ 1 coat iron oxide excluder.....	
14	Venetian red.....	8.0
888	Green (composite paint).....	8.0

REPORT OF SUB-COMMITTEE E ON LINSEED OIL.

This Sub-Committee reports as follows:

In 1909 four samples of linseed oil were taken under the direction of this Committee, and portions of these samples were re-bottled and sent out for analysis, the results obtained being reported at the meeting of the Society in that year. In addition to the portions which were bottled, two 5-gallon cans of each sample were held in reserve for further work. One can of each sample was bottled under the direction of your chairman for analysis in the early part of this year. These samples had been hermetically sealed for about two years. The purpose of the re-analysis was to discover how far they had changed during this time.

In addition to these four samples (numbered 1 to 4), twelve other samples were taken for analysis. The particulars of the sixteen samples as shown by their labels, etc., are as follows:

Sample
No.

- 1.....Sample of Linseed Oil taken at National Lead Co.'s Atlantic Branch Mill, Feb. 2, 1909. Bottled under direction of G. W. Thompson, Feb. 23, 1911. North American seed.
- 2.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill, Feb. 3, 1909. Bottled under direction of G. W. Thompson, Feb. 23, 1911: North American seed.
- 3.....Sample of Linseed Oil taken at American Linseed Co.'s South Chicago Mill, Feb. 6, 1909. Bottled under direction of G. W. Thompson, Feb. 23, 1911. North American seed.
- 4.....Sample of Linseed Oil taken at Archer-Daniels Linseed Co.'s Mill at Minneapolis, Feb. 13, 1909. Bottled under direction of G. W. Thompson, Feb. 23, 1911. North American seed.
- 5.....Sample of Linseed Oil taken at American Linseed Co.'s South Chicago Mill, June 15, 1910, by Edw. Gudeman and T. J. Bryan. Bottled under direction of G. W. Thompson, Mar. 1, 1911. North American seed.
- 6.....Sample of Linseed Oil taken at Archer-Daniels Linseed Co.'s Mill at Minneapolis, July 21, 1910, by A. S. Mitchell and F. G. Smith. Bottled under direction of G. W. Thompson. March 1, 1911. North American seed.

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Sample
No.

- 7.....Sample of Linseed Oil taken at Archer-Daniels Linseed Co.'s Mill at Minneapolis, about Sept. 30, 1910, by A. S. Mitchell. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American seed.
- 8.....Sample of Linseed Oil taken at Archer-Daniels Linseed Co.'s Mill at Minneapolis, Oct. 27, 1910, by F. G. Smith. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American seed.
- 9.....Sample of Linseed Oil taken at Archer-Daniels Linseed Co.'s Mill at Minneapolis, about Nov. 30, 1910, by A. S. Mitchell. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American seed.
- 10.....Sample of Linseed Oil taken at Archer-Daniels Linseed Oil Co.'s Mill at Minneapolis, about Dec. 31, 1910 by A. S. Mitchell. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American seed.
- 11.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill, Sept. 30, 1910, by H. Roehling. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American—largely Southwestern—seed.
- 12.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill about Oct. 31, 1910, by H. Roehling. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American Northwestern seed.
- 13.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill, Nov. 29, 1910, by H. Roehling. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American Southwestern seed.
- 14.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill, Dec. 29, 1910, by A. L. Winton. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American Northwestern seed.
- 15.....Sample of Linseed Oil taken at Hirst & Begley's Chicago Mill, Jan. 31, 1911, by A. L. Winton. Bottled under direction of G. W. Thompson, Feb. 18, 1911. North American Northwestern seed.
- 16.....Sample of Linseed Oil taken at National Lead Co.'s Atlantic Mill, Feb. 24, 1911, by A. H. Sabin. Bottled under direction of G. W. Thompson, Mar. 1, 1911. Argentine seed.

Samples 7 to 15 were taken with the idea of observing the variations in the constants of linseed as affected by their origin and the age of the seed from which they were made.

Sample 16 from Argentine Seed was taken so that a line could be obtained on its constants.

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It was decided that the analysis of these samples should be confined to the following determinations:

- | | |
|---|--|
| 1. Specific Gravity $\frac{15^{\circ}.5\text{ C.}}{15^{\circ}.5\text{ C.}}$
2. Specific Gravity $\frac{25^{\circ}\text{ C.}}{25^{\circ}\text{ C.}}$
3. Acid Number. | 4. Saponification Number.
5. Unsaponifiable Matter.
6. Refractive Index at 25° C.
7. Iodine Number (Hanus). |
|---|--|

The methods of analysis prescribed were those detailed in the report of 1909.

The following analysts or laboratories undertook to examine these samples:

1. G. W. Thompson, Chief Chemist, National Lead Company, 129 York St., Brooklyn, N. Y.
2. P. H. Walker, Chief Chemist Contracts Laboratory, Department of Agriculture, Bureau of Chemistry, Washington, D. C.
3. A. D. Little, Inc., 25 Broad St., Boston, Mass.
4. J. W. Kellogg, Chief Chemist, Bureau of Chemistry, Harrisburg, Pa.
5. Spencer Kellogg and Sons, Buffalo, N. Y.
6. S. S. Voorhees, Bureau of Standards, Washington, D. C.
7. John B. Tuttle, Bureau of Standards, Washington, D. C.

The results of their analyses are given in Tables I to VI, inclusive, pages 200-202.

It will be noted in studying these results that the ageing of Samples 1 to 4, inclusive, has not materially changed the constants of these samples except in the acid number, as is shown by the following comparative figures:

Property Considered.	Year.	Samples.			
		1	2	3	4
Specific Gravity $\frac{15^{\circ}.5\text{ C.}}{15^{\circ}.5\text{ C.}}$	1909	0.9347	0.9331	0.9331	0.9344
	1911	0.9342	0.9329	0.9331	0.9344
Specific Gravity $\frac{25^{\circ}\text{ C.}}{25^{\circ}\text{ C.}}$	1909	0.9298	0.9284	0.9285	0.9295
	1911	0.9299	0.9285	0.9286	0.9297
Acid Number	1909	1.15	3.50	1.94	1.58
	1911	1.39	4.38	2.79	1.80
Saponification Number	1909	190.6	190.1	190.1	190.2
	1911	190.7	190.8	190.2	190.4
Unsaponifiable Matter	1909	0.99	0.96	0.99	0.98
	1911	0.96	0.95	0.99	1.04
Refractive Index at 25° C.	1909	1.4800	1.4794	1.4797	1.4797
	1911	1.4799	1.4792	1.4793	1.4794
Iodine Number (Hanus)	1909	187.9	184.5	186.1	186.0
	1911	186.9	183.0	186.0	184.1

It would appear that the provisional specifications for linseed oil suggested in the 1909 report are fairly reliable for oils made from North American seed. The Committee is not qualified at this time to make recommendations of specifications for linseed oil from East Indian or Argentine seed. We do not find any material or rational difference in the oils produced from North American seed based on differences in the age of the seed.

The Committee has been unable so far to do any work on oil from damaged or off-grade seed.

In view of the fact that there is so great a variation in the iodine number and specific gravity of various samples of linseed oil, and the possibility of the adulteration of linseed oil with non-drying oils, without the oils being so affected in iodine number and specific gravity as to enable the analyst to say definitely that they have been adulterated, your Committee would urge the importance of the development of other tests for the purity of linseed oil, such as the hexabromide test, both on the oil and the fatty acids obtained from it, the acetyl value test, and the percentage of solid or saturated fatty acids present.

In the matter of boiled linseed oil, the Committee has made no tests of certified samples, but has considered the question carefully and agrees on the following points:

1. Boiled linseed oil should contain no appreciable amount of volatile matter.
2. The organic unsaponifiable matter in boiled linseed oil should not materially exceed that present in raw linseed oil.
3. While the Committee could not agree that resin compounds should be excluded from linseed oil, it did agree that if resin compounds are present, the amount should not appreciably exceed what would combine to form normal compounds with the lead and manganese present.

During the past year the Committee has offered samples of the 1909 oils to investigators for the purpose of developing these tests. Several sets of samples were sent out; the only report so far received has been one from the Lederle Laboratories, which is appended in full hereto without comment.

We append hereto (see Appendices to this report):

- I. A detailed report by the Lederle Laboratories (pages 203-207).
- II. Abstracts from S. S. Voorhees' report (pages 208-210).
- III. An exceedingly valuable report by H. W. Bearse of the Bureau of Standards on the Coefficient of Expansion of Linseed Oil (pages 211-222).

The thanks of your Committee and of the Society are due to the Department of Agriculture, Bureau of Chemistry, for the assistance rendered in taking the samples of linseed oil; to the American Linseed Company, the Archer-Daniels Company, Hirst and Begley, and the National Lead Company for the oil samples contributed; and also to the various analysts and investigators who have done work on these samples.

Respectfully submitted on behalf of the Sub-Committee,

G. W. THOMPSON,
Chairman, Sub-Committee E.

TABLE I.—SPECIFIC GRAVITY AT $\frac{15.5^{\circ}\text{C.}}{15^{\circ}.5\text{ C.}}$

Analyst	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	0.9344	0.9329	0.9329	0.9342	0.9328	0.9333	0.9337	0.9338	0.9345	0.9345	0.9324	0.9329	0.9323	0.9336	0.9340	0.9322
2.....	0.9319	0.9334	0.9333	0.9342	0.9324	0.9333	0.9341	0.9343	0.9348	0.9344	0.9330	0.9332	0.9627	0.9337	0.9347	0.9323
3.....	0.9342	0.9325	0.9328	0.9349	0.9329	0.9323	0.9338	0.9341	0.9340	0.9337	0.9316	0.9328	0.9317	0.9335	0.9340	0.9300
4.....	0.9343	0.9333	0.9332	0.9341	0.9322	0.9325	0.9340	0.9342	0.9345	0.9346	0.9332	0.9336	0.9327	0.9338	0.9345	0.9324
5.....	0.9336	0.9331	0.9333	0.9341	0.9325	0.9335	0.9340	0.9335	0.9344	0.9345	0.9325	0.9331	0.9325	0.9338	0.9340	.....
6.....	$\left\{ \begin{array}{l} a \\ b \end{array} \right.$	0.9339	0.9315	0.9336	0.9313	0.9326	0.9335	0.9333	0.9341	0.9341	0.9322	0.9326	0.9321	0.9333	0.9340	0.9317
7.....	0.9341	0.9326	0.9331	0.9343	0.9320	0.9332	0.9341	0.9342	0.9345	0.9346	0.9327	0.9331	0.9328	0.9340	0.9347	0.9324

SPECIFIC GRAVITY AT $\frac{25^{\circ}\text{C.}}{25^{\circ}\text{C.}}$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	0.9289	0.9283	0.9285	0.9297	0.9275	0.9285	0.9292	0.9293	0.9294	0.9296	0.9275	0.9287	0.9273	0.9289	0.9295	0.9275
2.....	0.9300	0.9287	0.9289	0.9300	0.9278	0.9288	0.9298	0.9299	0.9300	0.9286	0.9284	0.9290	0.9283	0.9292	0.9301	0.9278
3.....	0.9294	0.9284	0.9282	0.9294	0.9272	0.9286	0.9291	0.9283	0.9288	0.9282	0.9273	0.9278	0.9275	0.9287	0.9291	0.9264
6.....	$\left\{ \begin{array}{l} a \\ b \end{array} \right.$	0.9295	0.9273	0.9275	0.9293	0.9269	0.9283	0.9297	0.9304	0.9301	0.9285	0.9291	0.9285	0.9296	0.9306	0.9282
7.....	0.9299	0.9286	0.9286	0.9300	0.9276	0.9287	0.9295	0.9293	0.9297	0.9301	0.9285	0.9286	0.9285	0.9295	0.9304	0.9279
	0.9299	0.9284	0.9286	0.9296	0.9271	0.9285	0.9292	0.9297	0.9297	0.9298	0.9280	0.9284	0.9281	0.9292	0.9300	0.9278

(a).....Plummet. (b).....Pycnometer

TABLE II.—ACID NUMBER.

Analyst	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	1.57	4.45	2.79	2.04	4.72	2.07	2.38	1.54	2.00	1.77	0.97	0.91	1.03	0.92	1.78	1.49
2.....	1.5	4.3	2.7	1.9	4.3	2.1	2.1	1.4	1.8	1.5	1.0	0.9	0.8	0.8	1.6	1.2
3.....	1.25	4.40	2.64	1.86	4.45	2.08	2.17	1.56	1.82	1.59	1.07	1.09	0.97	1.43	1.67	0.98
5.....	1.41	4.47	2.88	1.83	4.73	2.12	2.07	1.61	1.93	1.57	1.00	1.00	1.02	0.92	1.80	....
6.....	1.40	4.48	2.94	1.82	4.48	1.96	2.10	1.56	1.68	1.82	0.94	1.12	0.98	1.12	1.68	1.40
7.....	1.23	4.20	2.81	1.68	4.55	1.92	1.89	1.27	1.74	1.29	0.94	0.85	0.83	0.74	1.70	1.13

TABLE III.—SAPONIFICATION NUMBER.

Analyst	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	190.2	191.5	191.2	190.1	190.8	190.6	191.6	191.3	191.3	191.7	190.5	190.4	190.6	190.7	190.2	190.6
2.....	191.1	190.3	189.9	190.2	190.7	191.8	191.1	189.1	190.6	192.0	192.3	190.3	191.1	191.3	192.7	190.5
3.....	190.0	190.0	188.0	190.0	190.0	189.0	191.0	190.0	191.0	194.0	190.0	188.0	193.0	189.0	190.0	190.0
4.....	191.5	192.5	191.8	192.0	191.9	191.8	191.5	192.8	192.9	192.8	192.0	191.8	192.5	190.9	191.8	191.1
5.....	192.4	191.8	191.2	191.2	191.8	191.2	191.9	191.7	190.7	190.3	191.0	190.9	191.0	192.5	192.5	....
6.....	189.4	189.1	189.0	189.3	189.9	189.3	190.5	190.0	190.2	190.0	189.6	189.8	189.8	190.0	190.5	190.2
7.....	190.5	190.7	190.1	190.3	191.0	191.2	191.2	191.2	191.5	191.3	190.8	191.3	190.3	191.3	191.2	190.9

TABLE IV.—UNSAPONIFIABLE MATTER.

Analyst	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	0.97	1.03	1.02	0.96	0.86	1.00	0.94	1.00	1.06	0.98	0.98	0.95	0.98	0.90	0.91	1.01
2.....	1.05	1.03	1.04	1.24	1.07	1.12	1.23	1.19	1.24	1.15	1.21	1.12	1.26	1.12	1.15	1.09
3.....	0.94	0.85	0.98	1.12	0.99	1.05	....	....	....	....	....	....	....	....	....	....
7.....	0.87	0.91	0.90	0.85	....	....	....	....	....	....	....	....	....	....	....	....

TABLE V.—REFRACTIVE INDEX AT 25° C.

Analyst.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	1.4802	1.4796	1.4795	1.4796	1.4787	1.4785	1.4790	1.4792	1.4792	1.4795	1.4790	1.4792	1.4790	1.4796	1.4796	1.4780
2.....	1.4793	1.4787	1.4789	1.4791	1.4783	1.4780	1.4788	1.4790	1.4790	1.4794	1.4786	1.4790	1.4786	1.4794	1.4793	1.4776
3.....	1.4805	1.4796	1.4798	1.4798	1.4791	1.4782	1.4798	1.4804	1.4800	1.4799	1.4796	1.4794	1.4794	1.4799	1.4798	1.4782
4.....	1.4799	1.4793	1.4797	1.4796	1.4788	1.4789	1.4790	1.4793	1.4794	1.4796	1.4789	1.4791	1.4792	1.4798	1.4799	1.4780
7.....	1.4795	1.4788	1.4788	1.4789	1.4778	1.4775	1.4784	1.4788	1.4787	1.4792	1.4785	1.4791	1.4787	1.4795	1.4794	1.4777

TABLE VI.—IODINE NUMBER (HANUS).

Analyst.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1.....	188.4	184.3	186.6	185.2	179.7	179.8	182.2	184.5	183.5	184.3	179.8	184.3	181.3	187.5	186.0	173.0
2.....	187.1	184.8	186.5	184.4	180.0	178.8	182.6	183.0	182.8	184.6	179.2	182.7	180.4	187.3	185.2	172.1
4.....	188.9	183.3	188.6	185.5	179.6	179.3	182.5	184.9	183.1	186.2	180.9	184.7	181.5	189.1	187.0	175.9
5.....	187.8	182.4	185.4	183.2	178.4	177.0	180.1	182.0	181.2	182.8	179.0	182.1	182.4	186.5	183.9	.....
6.....	185.6	182.6	185.6	183.5	178.5	175.9	180.9	181.9	181.6	184.1	178.3	183.7	179.5	185.9	184.4	170.7
7.....	183.8	180.8	183.6	182.6	177.5	176.7	179.8	181.8	181.2	183.5	179.0	183.1	179.1	185.7	183.0	170.5

APPENDICES TO REPORT OF SUB-COMMITTEE E.

I. REPORT OF LEDERLE LABORATORIES, NEW YORK CITY, ON LINSEED OIL RECEIVED FROM THE AMERICAN SOCIETY FOR TESTING MATERIALS.

1. SPECIFIC GRAVITY.

(Pyknometers of 50 cc. capacity were used.)

(a) At 15° C.

Sample 1.	Sample 2.	Sample 3.	Sample 4.
0.93407	0.93319	0.93307	0.93352

(b) At 25° C.

0.92983	0.92841	0.92864	0.92963
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2. TURBIDITY AND FOOTS IN CUBIC CENTIMETERS.

Twenty-five cubic centimeters of the unfiltered oil were allowed to stand 14 days in glass tubes 1 cm. in diameter. The tubes were supported in an upright position and stood in a light place at an average daily temperature of 81° F.

0.59	0.20	0.17	0.58
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3. BREAKING TEST.

Twelve cubic centimeters of the filtered oil were heated in a test tube $\frac{1}{8}$ in. by 6 ins. over a free flame to 300° C.

Breaks at 270° C. Does not break. Does not break. Breaks at 265° C.

4. PERCENTAGE OF MOISTURE AND VOLATILE MATTER.

(a) The samples were dried in 4-oz. Erlenmeyer flasks at 105° C. in a current of pure dry carbon dioxide. Two grams of unfiltered oil were used, drying to constant weight. Samples 1, 2 and 3 were constant after 2 hours, Sample 4 after 4 hours.

0.02	0.03	0.34	0.23
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5. PERCENTAGE OF ASH.

Ten grams of unfiltered oil were ignited in platinum dishes in a muffle at dull red heat.

0.139	0.031	0.033	0.190
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6. DRYING TEST ON GLASS IN HOURS.

Glass plates 7 cm. square and 1.5 to 3.0 mm. thick were dried at 110° C. and the oil applied while the glass was still warm; after cooling one hour in a dessicator, the plates were weighed and sufficient oil added to make 0.1 gram. The plates were kept under a ventilated bell jar in a

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light place. Drying was completed at an average daily temperature of 87° F. without a damp day intervening.

Sample 1.	Sample 2.	Sample 3.	Sample 4.
60	54	69	54

7. OXYGEN ABSORPTION, USING LEAD MONOXIDE.

Lead dishes of the prescribed size and shape were used in place of aluminum dishes. After the completion of the test, the dishes all appeared clean and bright.

(a) Five Grams Litharge.

Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.	Per cent.	Hours.
13.18	141	11.31	141	11.75	141	12.69	141

(b) Ten Grams Litharge.

13.74	141	13.29	141	12.78	141	13.40	141
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The detailed results are presented in Table I.

TABLE I.—PERCENTAGE OF OXYGEN ABSORPTION.

Time in Hours.	Sample 1.		Sample 2.		Sample 3.		Sample 4.	
	10 Grams Pb O.	5 Grams Pb O.	10 Grams Pb O.	5 Grams Pb O.	10 Grams Pb O.	5 Grams Pb O.	10 Grams Pb O.	5 Grams Pb O.
24	12.89	12.04	11.98	8.58	11.81	10.31	12.49	11.01
45	12.33	12.04	11.75	9.29	11.44	10.31	12.09	11.16
53	12.52	12.04	11.85	9.48	11.57	10.50	12.15	11.28
69	12.70	12.25	12.18	9.93	11.81	10.75	12.40	11.59
77	12.95	12.52	12.37	10.25	12.00	11.04	12.69	11.90
117	13.16	12.66	12.68	10.81	12.26	11.31	12.69	12.16
125	13.39	12.93	12.85	10.96	12.45	11.46	13.09	12.35
141	13.74	13.18	13.29	11.31	12.78	11.75	13.40	12.69
149	13.45	13.07	13.00	11.20	12.54	11.63	13.18	12.48
165	13.24	12.79	12.79	10.99	12.30	11.37	12.97	12.20
173	13.19	12.75	12.79	11.01	12.30	11.37	12.97	12.20
189	13.16	12.73	12.81	11.11	12.28	11.42	12.93	12.21
197	12.97	12.60	12.64	10.98	12.09	11.18	12.72	12.09
213	13.12	12.66	12.81	11.09	12.28	11.44	12.89	12.20
221	13.49	12.99	13.17	11.43	12.61	11.69	13.23	12.50
309	13.47	13.07	13.31	11.62	12.59	11.69	13.21	12.59
Oil taken (grams)	0.5165	0.5157	0.5205	0.5464	0.5374	0.5225	0.5273	0.5328

8. ACID NUMBER.

(Expressed in milligrams of KOH per gram of oil.)

Sample 1.	Sample 2.	Sample 3.	Sample 4.
1.20	3.60	2.50	1.40

9. SAPONIFICATION NUMBER.

(Expressed in milligrams of KOH per gram of oil.)

Saponification was effected by boiling one hour under a reflux condenser; corrections were applied for the action of the alkali on the glass.

190.6	190.4	192.0	192.7
191.1	189.9	191.8	192.5
190.6	190.2	192.1	191.8
190.8	190.2	191.9	191.3

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11. LIEBERMANN-STORCH TEST.

Sample 1.	Sample 2.	Sample 3.	Sample 4
Negative	Negative	Negative	Negative
Green	Green	Green	Green

12. REFRACTIVE INDEX.

In this determination, the Zeiss Butyro-Refractometer was used, using sodium light as a source of illumination. Determinations were made on the original oils and on the fatty acids prepared from the oils.

(a) Original Oils at 25° C.

1.4799	1.4793	1.4794	1.4797
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(b) Fatty Acids at 25° C.

1.4710	1.4703	1.4708	1.4704
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13. ACETYL VALUE.

Twenty cubic centimeters of the filtered oil were boiled with an equal volume of acetic anhydride for 2 hours under a reflux condenser, the flask being ground to the condenser. Both the distillation and filtration method were used.

(a) Distillation.

28.3	21.0	18.5	18.3
30.3	36.0 (?)	18.8	20.3

(b) Filtration.

29.0	23.0	45.0	40.9
21.5	21.3	39.2	34.3

In the distillation method, it appears that the results are fairly uniform, omitting the 36.0 value for Sample 2. In the filtration method, however, the results are far from satisfactory. From our experiments it seems that these discrepancies are due to free fatty acids coming through with the final filtrates, as indicated by the fact that the more turbid the filtrate the higher the result obtained. In the results given under (b), after adding the correct amount of standard acid to the soap solution, the resulting solutions were heated under a reflux condenser until quite clear and then filtered. Even this procedure did not yield perfectly clear filtrates.

In one case where the filtrate was fairly turbid, a value of 36.3 was obtained for Sample 1. In another case, where the filtrate was markedly turbid, a value of 55.6 was obtained for Sample 2. These results are excluded for this reason.

Lewkowitsch* makes the following statement:

"In order to facilitate the separation of the insoluble fatty acids in the filtration process, it will be found useful to add a slight excess of min-

* *Chem. Tech. and Anal. of Oils, Fats and Waxes*, Vol. I, 1904, p. 270.

eral acid. Of course this amount must be measured accurately and deducted from the alkali required for determining the dissolved acids."

We made no determinations by adding more than the equivalent quantity of acid, but it seems that work in this direction would be of some value in the filtration method.

14. HEXABROMIDE TEST.

(a) Bromine Precipitate (Tolman's Method), per cent.

Sample 1.	Sample 2.	Sample 3.	Sample 4.
55.93	57.01	58.48	49.31

(b) Melting Point of Bromine Precipitate, degrees Centigrade.

137	138	138.5	136
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In addition to the above determinations, the hexabromides of the fatty acids were also determined according to the method of Hehner and Mitchell as described in Lewkowitch.*

(c) Hexabromides of Fatty Acids (Hehner and Mitchell), per cent.

35.08	31.79	36.31	35.46
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Our experience with this determination leads us to believe that the volumes of reagents used is of importance. The following series were conducted as follows:

Thirty centimeters of glacial acetic acid were added for every gram of fatty acids used,* adding bromine in excess. After standing for three hours in the refrigerator, the bromides were filtered through a Gooch crucible and washed successively with 5 cc. each of chilled glacial acetic acid, ethyl alcohol and ethyl ether. The crucible was dried one hour at 100° C. and weighed. The results obtained are given under (d).

(d) Hexabromides of Fatty Acids (Hehner and Mitchell), per cent.

29.94	28.16	30.41	31.29
29.87	27.38	29.75	31.54
		32.51 (?)	

(e) Melting Point of Hexabromides of Fatty Acids, from Determinations (d), degrees Centigrade.

178	178.5	178.3	178.4
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Inasmuch as the bromides are not pure white as obtained above, another series of determinations was made, in which the bromides were washed with a still further quantity of ethyl ether until pure white. The results are given under (f).

(f) Hexabromides of Fatty Acids (Hehner and Mitchell) washed until pure white, per cent.

28.33	26.92	27.67	28.79
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A larger quantity of hexabromides of the fatty acids was prepared qualitatively and washed until pure white. The melting points are given under (g).

**Ibid.*, p. 365.

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(g) Melting Point of Hexabromides of Fatty Acids, degrees Centigrade.

Sample 1.	Sample 2.	Sample 3.	Sample 4.
177.3	177.8	177.3	177.7

It is evident from these results that the determinations as carried out under (d), with the exception of the 32.51 per cent. on Sample 3, show quite uniform results, and it is our opinion that a further study along these lines is of extreme importance.

15. IODINE NUMBER.

(a) Hanus Method.

186.1	182.1	185.3	183.6
185.4	182.1	184.0	183.8
<hr/>	<hr/>	<hr/>	<hr/>
185.75	182.1	184.65	183.7

(b) Wijs Method.

187.3	183.9	186.9	184.6
187.2	184.4	187.1	185.8
<hr/>	<hr/>	<hr/>	<hr/>
187.25	184.15	187.0	185.2

In both the Hanus and Wijs method, the solution of the oil was allowed to remain in contact with the reagent for one hour in a dark place before titration.

Respectfully submitted,

JOSEPH A. DEGHUEE, PH.D.,
Director, Department of Chemistry.

PAUL POETSCHKE,
Ass't Director, Department of Chemistry.

II. COMMENTS BY S. S. VOORHEES.*

SPECIFIC GRAVITY.

(a) *Plummet*.—The specific gravity was obtained by means of a plummet approximately 5 cc. in volume, containing an accurate thermometer. The weighings were made on an accurate analytical balance. The determination was first made at 25° C., since that temperature was nearest the room temperature. The temperature of the oil in the cylinder was raised two or three degrees above 25° C., the cylinder placed on the balance with the plummet in the oil, and when the temperature of the oil fell to 25° C. the weighing was quickly made.

To obtain the specific gravity at 15° C. the oil was cooled in chilled water to about 13° C., the cylinder placed in the balance case with plummet suspended in the oil, and when the temperature rose to 15° C. the weight was taken. The plummet was standardized in pure water at these temperatures in the same manner.

(b) *Pyknometer*.—These determinations were made by means of three 25-cc. and four 50-cc. pyknometers provided with thermometers and perforated caps. The pyknometers were filled with the oil chilled to 2° or 3° below 15° C. The thermometer was inserted and the temperature allowed to rise to 15° C. When that temperature was reached the pyknometer was capped, cleaned with gasoline, wiped dry, and weighed.

To determine the specific gravity at 25° C., the caps were removed and the pyknometer placed in a room having a temperature of about 30° C. When the thermometer showed the temperature of the oil to be 25° C. the pyknometers were again capped, cleaned with gasoline, wiped dry, and weighed as before. The standardization of the pyknometers with pure water was conducted in the above manner.

ACID VALUE.

Ten grams of oil were weighed into an Erlenmeyer flask and 25 cc. of neutralized alcohol added, brought to a boil on the steam plate, and titrated with N/2 KOH and phenolphthalein as indicator to distinct coloration.

* These comments refer to the determinations, etc., made by Mr. Voorhees, shown in Tables I to VI, inclusive, of this report, pp. 200-202.

LIEBERMANN-STORCH TESTS.

The alcoholic extract of the above determination was evaporated to dryness and tested for rosin. In every case an apple-green coloration was obtained.

SAPONIFICATION VALUE.

A water-white standard alcoholic KOH and an $N/2$ HCl, standardized by $AgNO_3$ and weighing $AgCl$ in a Gooch crucible, were used. Five grams of oil were accurately weighed out in an Erlenmeyer flask, 50 cc. of alcoholic KOH run in from a standard pipette, a glass tube reflex condenser inserted, and the flask heated on the water bath for one hour. Then it was cooled and titrated with $N/2$ HCl using phenolphthalein as an indicator.

VOLATILE MATTER AT $110^\circ C$.

Ten grams of oil were accurately weighed in a porcelain crucible and heated for 2 hours in the oven at $110^\circ C$.

Sample No.	Per cent. Loss.	Sample No.	Per cent. Loss.
1.....	0.05	9.....	0.04
2.....	0.03	10.....	0.05
3.....	0.13	11.....	0.06
4.....	0.04	12.....	0.04
5.....	0.13	13.....	0.04
6.....	0.06	14.....	0.04
7.....	0.04	15.....	0.05
8.....	0.04	16.....	0.05

PERCENTAGE OF ASH.

The oil from the volatile determinations was ashed and the ash tested for manganese by means of ammonium persulphate. The manganese coloration was obtained in every case and in some cases was quite marked.

Sample No.	Per cent.	Sample No.	Per cent.
1.....	0.16	9.....	0.19
2.....	0.02	10.....	0.21
3.....	0.03	11.....	0.05
4.....	0.16	12.....	0.03
5.....	0.03	13.....	0.03
6.....	0.18	14.....	0.04
7.....	0.18	15.....	0.16
8.....	0.16	16.....	0.16

IODINE NUMBER.

About 0.15 gram of oil was weighed into freshly ignited porcelain boats, introduced into tightly stoppered bottles of 500-cc. capacity, and dissolved in 10 cc. of chloroform. Twenty-five cubic centimeters of Hanus solution were added and allowed to stand 30 minutes, the bottle being shaken three times during that period. At the end of 30 minutes 10 cc. of 10-per cent. KI solution were added, the bottle shaken, 100 cc. of water added, and the excess of iodine titrated with N/10 thiosulphate solution using starch as an indicator. The excess of iodine was about 59 per cent. of the total amount added. The thiosulphate solution was standardized with N/10 potassium dichromate prepared by dissolving 4.90838 grams of the pure salt dried at 130° C. in one liter of distilled water. Blanks were run with each set of determinations.

S. S. VOORHEES, *Engineer-Chemist*

III. THE DENSITY AND THERMAL EXPANSION OF LINSEED OIL.

BY H. W. BEARSE.

INTRODUCTION

An investigation of the density and thermal expansion of linseed oil was undertaken at the Bureau of Standards in response to a demand for more complete and accurate knowledge of these physical constants as an aid in setting up standards of purity of this substance. It was hoped also that a comprehensive study might reveal some definite relations between different physical properties, such, for example, as density and coefficient of expansion.

The work was very greatly aided by the American Society for Testing Materials, from whom the samples were secured through the courtesy of Mr. S. S. Voorhees, a member of the special committee on linseed oil and a member of this Bureau.

EXPERIMENTAL WORK.

Sixteen samples, of known origin, were secured and their densities determined at 10° , 20° , 30° , and 40° C. by the method of hydrostatic weighing, that is, by weighing in the sample a sinker of known mass and volume.

The apparatus used in making the density determinations was that devised by Mr. N. S. Osborne, formerly of this Bureau, and used by him in the work on the density and thermal expansion of ethyl alcohol.

ARRANGEMENT OF APPARATUS.

The arrangement of apparatus is as follows: The sample under investigation and the sinker are placed in a tube having a length of about 50 cm. and a diameter of 2 cm., and surrounded by a temperature bath kept in constant circulation by a small propeller. This inner bath is surrounded by a second bath, which is also kept in constant circulation and whose temperature can be maintained constant or varied at will over a range of 10° to 40° C., by means of a thermostat and an electric heating coil and a copper coil through which refrigerating brine may be passed. The outside containing vessel for the various tubes and baths is a

large unsilvered Dewar cylinder provided with a brass cap suitable for supporting the inner parts of the apparatus. The cylinder is mounted in a vertical position and covered with a layer of nickeled paper through which windows are cut to permit observations to be made.

The temperature is read on two mercurial thermometers suspended in water in a tube placed symmetrically with that containing the sample of oil. The thermometers are so mounted on a movable cap that by its rotation they may be successively brought into position for reading, which is done with the aid of a long-focus microscope. The object of placing the thermometers in a tube instead of directly in contact with the water of the inner circulating bath is to eliminate, as far as possible, errors due to temperature lag within the densimeter tube. Since the sample under test is separated from the circulating bath by the densimeter tube, the thermometers should be separated from it by a similar tube, in order that when a constant temperature is indicated by them the same constant temperature shall obtain within the densimeter tube.

The same thermometers were used repeatedly over the same temperature range, and from previous experience with these thermometers over this range, it was thought unnecessary to take ice-point readings after each reading of the thermometers. Ice-point readings were, however, taken occasionally throughout the work and these, together with an extended series obtained earlier in the year, were found to be sufficiently concordant to warrant their use in fixing the corrections to be applied at the various temperatures.

The thermometers used were:

- B. S. No. 4653, made by Tonnelot in 1888, of verre dur glass.
- B. S. No. 2040, " " Haak " 1906, " Jena 16^m glass.
- B. S. No. 264, " " Richter " 1902, " " " "

All thermometers were graduated to 0°.1 C.

The volume of the sinker used in making the density determinations was calculated from its mass and its apparent weight in twice distilled water at 4°, 10°, 20°, 30°, and 40° C., assuming Chappuis' values for the density of water. The equation

$$V_t = V_x + \alpha(t-x) + \beta(t-x)^2$$

was assumed to represent sufficiently well the expansion of the

sinker. The values of V_x , α and β obtained by making a least squares reduction of the observations were:

$$V_x = V_{24} = 47.7174 \text{ cc.}$$

$$\alpha = 0.0011001$$

$$\beta = 0.000009734$$

Therefore,

$$V_t = 47.7174 + 0.0011001(t - 24) + 0.000009734(t - 24)^2,$$

from which the calculated volumes are as follows:

Temperature, deg. Cent.	Volume, cc.
10.....	47.7022
20.....	47.7130
30.....	47.7240
40.....	47.7352

The sinker is suspended by a hook from a small secondary sinker attached to a wire let down from one pan of the balance. The secondary sinker has a mass sufficient to keep the suspension wire straight and in its proper position, and is always immersed in the liquid whether the larger sinker (of known mass and volume) is attached or not.

The suspension wire, at the point where it passes through the surface of the liquid, has a diameter of 0.3 mm. and is covered with a layer of unpolished gold by electro-deposition. In the case of liquids which imperfectly wet the suspension, this roughening of the surface is essential, but with oil it is probably unnecessary.

All weighings were made by the method of substitution, that is, a constant mass was kept on one pan of the balance and the weighings made on the other, sufficient weights being placed on the pan to secure equilibrium, first with the sinker attached and then detached. The weighings were made on a Rueprecht analytical balance (B. S. No. 5156) having a capacity of 200 grams and a sensibility of 0.08 gram per division when undamped. When the immersed sinker was attached the sensibility was greatly reduced, especially at the lower temperatures, owing to the viscosity of the oil. At the higher temperatures, weighings could be made to a few tenths of a milligram, but at 10° C. difficulty was experienced in weighing closer than from one to two milligrams.

Of the weights used, those of less than 1 gram were a special set provided with the balance, and were manipulated by keys

on the outside of the balance without opening the case. Those between 1 and 100 grams were platinum-plated brass weights (B. S. No. 5157). These weights, used only for special purposes, were re-calibrated a few months before the beginning of this work, and the maximum error of any possible combination of weights was found to be so small in comparison with accidental errors as to be negligible.

All weighings were reduced to vacuo by means of a special device originally designed for use in correcting weighings of water in the test of volumetric apparatus. This apparatus consists of a glass bulb of such a volume (about 900 cc.) that when suspended from one arm of a balance and counterpoised against a brass weight of equal mass, the number of milligrams that must be added to the pan from which the bulb is suspended to secure equilibrium is equal to the buoyancy on a liter of water weighed in air against brass weights. This buoyancy constant when divided by 881.3 (which is the difference in volume between the brass weights and the glass bulb) gives the air density. For convenience, a table is arranged giving the air density corresponding to any observed buoyancy constant.

METHOD OF PROCEDURE.

In making the density determinations the method of procedure was as follows: The water in the outside circulating bath was first brought to the desired temperature. When the thermometers in the inner tube indicated a constant temperature, it was assumed that the liquid in the densimeter tube was at the same constant temperature, and observations were begun. First, a weighing was made with the sinker suspended in the sample, then the temperature was observed on each of the two thermometers; next a weighing was made with the sinker off, then a second with the sinker on, and after that a second observation of temperature. The temperature was then changed to the next point of the series, and here the same order was followed, except that at 40° only one thermometer was read. After completing the observations at the four temperatures, 10°, 20°, 30°, and 40° C., the density at each temperature was calculated from the weighings and the observed temperatures. The mean of the differences between the weighings with the sinker on and off was taken as the apparent weight of the sinker in the sample at the temperature of observation, this temperature being

TABLE I.—OBSERVATIONS AND CALCULATION OF DENSITIES, SAMPLE 6.

Date. 4-13-1911.	Temperature, deg. Cent.		Corrected Temperature.	Balance Reading, grams.	Appar- ent Weight, grams.	Air Buoyancy.	Corrected Weight, grams.	Weight of Sinker (in vacuo), grams.	Weight of Dis- placed Liquid, grams.	Volume, cc.	D_t (Reduced)	D_t
	No. 2040	No. 4653										
12:30 p.m.	10.055	9.975	10.047	38.5045	55.3263	1052	55.3185	99.9990	44.6805	47.6805	0.936689 (10° C.)	0.936655 (+34)
	10.028	9.972	10.020	93.8308	55.3263	25°.8						
	(-0.008)	(+0.091)	10.049			25°.2						
1:40 p.m.	19.870	19.828	19.867	38.1802	55.6389	0.001182	55.6317	99.9990	44.3673	47.71282	0.929794 (20° C.)	0.929882 (-88)
	19.875	19.848	19.872	93.8191	55.6401	-0.0078	55.6317	99.9990	44.3673	47.71282		
	(-0.003)	(+0.036)	19.872	38.1790	55.6395							
2:40 p.m.	29.960	29.960	29.955	37.8496	55.9576	-0.0078	55.9503	99.9990	44.0487	47.72394	0.922964 (30° C.)	0.922990 (-26)
	23.955	29.692	29.960	93.8072	55.9586		55.9503	99.9990	44.0487	47.72394		
	(-0.005)	(+0.005)	29.962	37.8486	55.9581							
3:25 p.m.	No. 264						56.2606	99.9990	43.7384	47.73492	0.916277 (40° C.)	0.916277 (-108)
	39.780	.....	39.747	37.5280	56.2682	-0.0079	56.2606	99.9990	43.7384	47.73492		
	39.795	.....	39.762	93.7862	56.2688							
	(-0.033)	.....	39.754	37.5274	56.2686							

NOTE: In the column headed "Air Buoyancy,"

1052—observed buoyancy constant.

25°.8—temperature at the buoyancy bulb.

25°.2—temperature in the balance.

1042—buoyancy constant corrected for temperature.

[0.001182—air density.

0.0078—buoyancy correction to the apparent weight, in grams.

taken as the mean of the four corrected thermometer readings. The apparent weight of the sinker was corrected for the buoyancy of the air by subtracting from it the volume of the brass weights multiplied by the air density. This corrected weight of the sinker in the sample, subtracted from its weight in vacuo, gives the weight of the liquid displaced by the sinker; and the weight of this displaced liquid divided by its volume—that is, the volume of the sinker—gives the density of the sample at the temperature of observation. Or, if expressed in the form of an equation,

$$D_t = \frac{W - \frac{(w-w_1) + (w-w_2)}{2} \left(1 - \frac{\rho}{8.4}\right)}{V_t}$$

in which

D_t = density of sample at the temperature t .

W = weight of sinker in vacuo.

w = weighing with sinker off.

w_1 and w_2 = weighings with sinker on.

ρ = air density.

8.4 = assumed density of brass weights.

V_t = volume of sinker at temperature t .

After calculating the density of a sample at 10°, 20°, 30°, and 40° C., it was assumed that the rate of expansion could be represented by the equation

$$D_t = D_x + \alpha(t-x) + \beta(t-x)^2,$$

and a least squares reduction was applied to the measured densities in order to find D_x , α , and β , and the most probable value of the density at each temperature.

Table I contains the observations on an average sample, No. 6. The reduction of these observations is also given as follows:

REDUCTION OF OBSERVATIONS, SAMPLE 6.

t	$C_1 = t - t_m$	C_1^2	$C_2 = C_1^2 - (C_1^2)_m$	C_2^2	D_t	$N = D_t - (D_t)_m$	$C_1 N$	$C_2 N$
10	-15	225	100	10000	0.936689	+0.010300	-0.15450	+1.0300
20	-5	25	-100	10000	0.929794	+0.003405	-0.01702	-0.3405
30	5	25	-100	10000	0.922964	-0.003425	-0.01712	+0.3425
40	15	225	100	10000	0.916109	-0.010280	-0.15420	-1.0280
$t_m = 25$		$(C_1)_m = 500$ $= 125$		40000	0.926389 $= (D_t)_m$		-0.34284	+0.0040

$$\begin{aligned}
 500 \alpha &= -0.34284 & 40000 \beta &= +0.004 \\
 \alpha &= -0.0006857 & \beta &= +0.0000001 \\
 D_{25} + 125 \beta &= (D_t)_m \\
 D_{25} - D_{25} &= 0.926389 - 0.000012 \\
 D_{25} &= 0.926377 \\
 D_t &= D_{25} + \alpha(t-25) + \beta(t-25)^2 \\
 D_t &= 0.926377 - 0.0006857(t-25) + 0.0000001(t-25)^2
 \end{aligned}$$

t	$t-25$	$(t-25)^2$	$\alpha(t-25)$	$\beta(t-25)^2$	D_t		Observed minus Calculated.
					Calculated.	Observed.	
10	-15	225	+0.010286	+0.000022	0.93668	0.93669	1
20	-5	25	+0.003428	+0.000002	0.92981	0.92979	-2
30	5	25	-0.003428	+0.000002	0.92295	0.92296	1
40	15	225	-0.010286	+0.000022	0.91611	0.91611	0

$$D_t = D_{25} + \alpha(t-25) + \beta(t-25)^2 \quad (1)$$

Taking for α and β the mean values of the sixteen samples, the general equation becomes

$$D_t = D_{25} - 0.0006847(t-25) + 0.00000012(t-25)^2$$

If it is desired to reduce the expansion to a single term, for use over a short temperature range, this may be done by differentiating the general equation and combining α and β into a single term α' , which will be different for different temperatures.

$$\begin{aligned}
 D_t &= D_{25} + \alpha(t-25) + \beta(t-25)^2 \\
 \frac{dD_t}{dt} &= \alpha + 2\beta(t-25) = \alpha' \quad (2)
 \end{aligned}$$

Substituting for t the values 10, 15, 20, 25, 30, 35, and 40, we have for the rate of change of density at the different temperatures the following values:

Temperature, deg. Cent.	Change per deg. Cent.
10.....	0.0006883
15.....	0.0006871
20.....	0.0006859
25.....	0.0006847
30.....	0.0006835
35.....	0.0006823
40.....	0.0006811

The densities of the sixteen samples of linseed oil, reduced to the basis of specific gravity at $15^{\circ}.5/15^{\circ}.5$ C. and at $25^{\circ}/25^{\circ}$ C., are as follows:

Sample No.	Density.	
	Sp. Gr. $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.	Sp. Gr. $\frac{25^{\circ}}{25^{\circ}}$ C.
1.....	0.93499	0.93028
2.....	0.93309	0.92840
3.....	0.93325	0.92857
4.....	0.93447	0.92978
5.....	0.93221	0.92751
6.....	0.93379	0.92909
7.....	0.93428	0.92960
8.....	0.93420	0.92951
9.....	0.93458	0.92992
10.....	0.93471	0.93002
11.....	0.93317	0.92849
12.....	0.93336	0.92868
13.....	0.93272	0.92805
14.....	0.93414	0.92944
15.....	0.93463	0.92992
16.....	0.93238	0.92771

Table II is a summary of the results on the sixteen samples arranged in the increasing order of their densities. It will be seen from the tabulated results that the coefficient of expansion as determined from sixteen samples varies over rather narrow limits; for example, at 25° C. the change of density per degree lies between 0.0006823 and 0.0006873, the mean of the sixteen samples being 0.0006847. It will also be seen that the rate of change of density is, in general, greater at the lower than at the higher temperatures, Sample 9 being the only exception. In regard to this exception, it should perhaps be stated that the tabulated values of α , β , and D_{25} are the means of two independent determinations on different portions of Sample 9 and that these two determinations were in substantial agreement. The truth of the exception would, therefore, seem to be established. It further appears from the tabulated results that the coefficient of expansion is somewhat greater for the heavier than for the lighter oils; the mean of the first half of the series being 0.0006842 at 25° C. and for the last half 0.0006852. This fact, however, should not be

TABLE II.—DENSITY AND THERMAL EXPANSION OF LINSEED OIL AT TEMPERATURES BETWEEN 10° AND 40° C.
(Arranged in increasing order of the densities.)

Sample No.	Density.					$\alpha \times 10^7$	$\beta \times 10^9$
	10° 4° C.	20° 4° C.	30° 4° C.	40° 4° C.	25° 4° C.		
5	0.93513	0.92823	0.92139	0.91460	0.92480	-6844	+262
16	0.93526	0.92841	0.92158	0.91475	0.92499	-6836	+50
13	0.93561	0.92875	0.92193	0.91514	0.92534	-6823	+192
2	0.93598	0.92911	0.92226	0.91543	0.92568	-6851	+90
11	0.93606	0.92920	0.92235	0.91552	0.92578	-6848	+58
3	0.93614	0.92928	0.92244	0.91561	0.92586	-6843	+90
12	0.93624	0.92938	0.92255	0.91573	0.92596	-6838	+95
6	0.93668	0.92981	0.92295	0.91611	0.92638	-6857	+100
14	0.93704	0.93016	0.92329	0.91642	0.92672	-6875	+38
8	0.93710	0.93022	0.92338	0.91657	0.92680	-6843	+168
7	0.93716	0.93031	0.92347	0.91664	0.92688	-6840	+78
4	0.93738	0.93049	0.92365	0.91686	0.92706	-6842	+240
9	0.93746	0.93062	0.92377	0.91691	0.92720	-6850	-88
15	0.93755	0.93063	0.92376	0.91689	0.92720	-6852	+320
10	0.93761	0.93073	0.92389	0.91707	0.92730	-6844	+155
1	0.93789	0.93100	0.92413	0.91727	0.92756	-6873	+78
				Mean	0.92634	-6847	+120

given great weight, as three samples in the first half fall above and four in the last half below the mean value.

It appears from this investigation that if the density of any sample of pure linseed oil be determined at 25° C., its density at any other temperature between 10° and 40° C. may be calculated within the limits of ordinary experimental errors by use of the general equation

$$D_t = D_{25} + \alpha(t - 25) + \beta(t - 25)^2,$$

in which α is taken as -0.0006847 and β as +0.000000120. Or, the density may be measured at any other convenient temperature and for short temperature intervals the corresponding value of α' used. For example, to reduce from 19° C. to 20° C. the value 0.0006859 would be used.

It should be borne in mind that all values in this paper are referred to water at 4° C. as unity and not, as is sometimes done, referred to water at the same temperature. If, however, as is sometimes convenient, density determinations are referred to water at the same temperature, they may, of course, be reduced to the basis of 4° C. by multiplying by the density of water at the temperature of observation.

In regard to the accuracy of the results given in this paper, it is believed that at all temperatures except 10°C . the values of density are correct to within three units of the fifth decimal place, and at 10°C . to within five units of the fifth decimal place. At 10°C . the method employed was not so satisfactory as it was at the higher temperatures, owing to the increased viscosity of the oil. As there is also some objection to the use of this method on those samples in which a large amount of suspended matter is present, it is expected that in the immediate future a series of measurements will be made with a special pyknometer of the Sprengle type, designed for the temperature bath already described, to determine the magnitude of the change of density caused by the settling out of the suspended matter.

A comparison of the values of the coefficient of expansion given in this paper with those generally accepted will show that the values given by Allen* and by Andés† appear to be too small; they are respectively 0.000649 and 0.00063 per degree Centigrade. Ennis‡ gives 0.00045 per degree Fahrenheit, which is equal to 0.00081 per degree Centigrade and is undoubtedly too large. The low value given by Allen may be explained, at least in part, by his assumption that the rate of expansion is the same at all temperatures. He determined the specific gravity at two widely separated temperatures, and took the mean value thus found as the coefficient of expansion. Since the present work has shown that the rate of expansion is less at the higher than at the lower temperatures, the mean coefficient given by Allen is obviously too low for ordinary laboratory temperatures.

Hurst§ gives the value 0.00065 as the change of density per degree Centigrade. Maire|| gives the value of 0.00035 per degree Fahrenheit (0.00063 per degree Centigrade), but he applied the temperature correction in the wrong direction. The most complete and definite results found are those obtained by Sabin.¶ He gives the rate of change between $15^{\circ}.5$ and 28°C . as 0.000692, and between 28° and 100°C . as 0.000720 per degree Centigrade.

* Commercial Organic Analysis, Vol. I, Part 1.

† Boiled Oils, Drying Oils, etc.

‡ Linseed Oil and Other Seed Oils.

§ Painters' Colors, Oils and Varnishes.

|| Modern Pigments and Their Vehicles.

¶ Technology of Paint and Varnish.

This value of the expansion between $15^{\circ}.5$ and 28° C. is in better agreement with the results of the present investigation than any other yet found. The increased coefficient at high temperatures, reported by Sabin, was not confirmed by this work. It is possible, of course, that the coefficient does increase at temperatures higher than that to which this work was carried.

A majority of the references consulted give the limits of the specific gravity of pure raw linseed oil at $15^{\circ}.5$ C. as 0.931 to 0.937, referred to water at $15^{\circ}.5$ C. as unity. The limits found in the present investigation, if reduced to the same temperature basis, are 0.9322 and 0.9350.

From the scant data available, and in the inadequacy of the usual definitions of specific gravity, it is impossible to make a satisfactory comparison of published results. For example, by the term "coefficient of expansion" one author means the change of specific gravity per degree Centigrade divided by the specific gravity; another means the change of specific gravity per degree, all specific gravities being referred to water at the temperature of observation; while still another means the change of specific gravity per degree, the specific gravities being referred to water at two different temperatures—that is, the coefficient of expansion last defined is the difference between the expansion of the oil in question and that of water.

The writer wishes to protest most vigorously against these many and varied practices, and to suggest that all specific gravities be referred to water at some one definitely stated temperature (preferably 4° C., in order that specific gravity and density expressed in grams per cubic centimeter may become identical), and that the coefficient of expansion of a liquid be understood to mean the change of density per degree Centigrade.

A word of explanation in regard to this proposed uniform temperature basis for all specific gravity determinations may perhaps not be out of place, as the objection is often raised, by chemists and others, that 4° C. is not a convenient temperature at which to make determinations. Now in reality that is no objection at all, for the reason that determinations need not be made at 4° C., but may be made as usual at any convenient temperature and then reduced to the basis of water at 4° C. as unity, by multiplying by the ratio of the densities of water at the temperature of observation

and at 4° C. Since expressing specific gravities in terms of water at a definite temperature simply means that a definite value has been chosen for the unit to be employed, it follows that if the relative size of the different units be known, the specific gravities may be expressed in terms of water at any desired temperature.

Suppose, for example, that it is desired to determine by the use of the pyknometer the specific gravity of a sample of oil at 20° C. in terms of water at 4° C. as unity (that is, the density at 20° C.). It is only necessary to determine it at 20° C. in terms of water at 20° C. in the usual manner, and then multiply the observed value by the density of water at 20° C. Suppose the value of the specific gravity at 20°/20° C. is found to be 0.93182; then the value at 20°/4° C. will be $0.93182 \times 0.998234 = 0.93017$.

For other temperatures the transformation is equally simple:

$$\text{Specific Gravity at } \frac{15^{\circ}.5}{4^{\circ}} \text{C.} = \text{Specific Gravity at } \frac{15^{\circ}.5}{15^{\circ}.5} \text{C.} \times 0.999050.$$

$$\text{Specific Gravity at } \frac{25^{\circ}}{4^{\circ}} \text{C.} = \text{Specific Gravity at } \frac{25^{\circ}}{25^{\circ}} \text{C.} \times 0.997077.$$

REPORT OF SUB-COMMITTEE F ON THE DEFINITION OF
TERMS USED IN PAINT SPECIFICATIONS.

In this report only general terms have been included. Other terms are under consideration and will, it is hoped, be reported on at later meetings of the Society.

Standard.—A term designating a quality or qualities specified.

Equal to.—The use of this term should be avoided if possible.

Pure.—Standard, without adulteration.

Commercially Pure.—Is not defined and should not be used in specifications as it involves the absence of "*standard*."

Adulteration.—The partial substitution of one substance for another.

Adulterant.—A substance partially substituted for another.

Bulk.—The bulk of a pigment shall be considered as the total volume of the pigment and the voids, and varies inversely as the specific gravity of that volume.

Voids.—The space between the particles of a pigment, even though occupied by air or by a vehicle, whether liquid or dried.

Opacity.—The obstruction to the direct transmission of visible light afforded by any substance—comparison being made with sections of equal thickness. The opacity in the case of pigments should be considered as referable to their opacity in a vehicle under standard conditions.

Crystalline.—Having a definite structure referable to one of the systems of crystallography.

Amorphous.—The opposite of crystalline.

Paint.—A mixture of pigment with vehicle, intended to be spread in thin coats for decoration or protection, or both.

Pigment.—The fine solid particles used in the preparation of paint, and substantially insoluble in the vehicle.

Vehicle.—The liquid portion of a paint.

Volatile Thinner.—All that portion of a paint, except water, which is volatile in a current of steam at atmospheric pressure.

Non-Volatile Vehicle.—The liquid portion of paint, excepting water, which is not a volatile thinner by the above definition.

Tinting Strength.—The relative power of coloring a given quantity of paint or pigment selected as standard for comparison.

Water.—Dissolved water or water not definitely or chemically combined.

Dry.—Containing no uncombined water.

Specific Gravity.—The relative weight of a unit volume of a substance compared with the weight of the unit volume of water at defined temperatures.

Color.—A generic term including the colors of the spectrum, white and black, and all tints, shades and hues which may be produced by their admixture.

Tint.—A color produced by the admixture of a commercial coloring material, excepting white, with a white pigment or paint, the white predominating.

Drying.—The solidification of a liquid, independent of change in temperature.

Respectfully submitted on behalf of the Sub-Committee,

G. W. THOMPSON,
Chairman, Sub-Committee F.

REPORT OF SUB-COMMITTEE J ON THE TESTING OF
WHITE PAINTS.

This Sub-Committee begs to submit the following report:

It was decided in conducting these tests to limit them strictly to white paints, not to use any tints. The paints are to be applied on both sides of yellow poplar panels, 8 by 1 by 36 ins. Three of these single pieces are to be clamped together, forming a temporary surface 24 by 36 ins. for the application of the paint. The paint is to be applied at a definite spreading rate; three coats with at least seven days time between coats for drying. Two sets of these panels, each consisting of three pieces painted on both sides, are to be used for each test. These panels are to be exposed in a fence or rack to be constructed as follows: Posts of locust or red cedar, 10 ft. 10½ ins. long by approximately 6 ins. in diameter, planted in rough concrete 2½ ft. deep, 10 ft. 6 ins. in the clear between the posts, are to be connected by three lines of 2 by 4-in. yellow-pine stringers. The top stringers are to be spiked to the top of the posts; the middle and bottom stringers are to be notched in and spiked with a clearance of 36½ ins. Two strips of 1-in. quarter-round molding are to be fastened with brass screws to the upper surface of the bottom stringers, to the upper and lower surface of the middle stringers, and to the lower surface of the top stringers, with a clearance of 1 in. between parallel lines of molding. The whole frame is to be painted with three coats of red oxide of iron ground in linseed oil. The panels after having been painted and dried under cover are to be placed in the rack by removing one of the strips of molding, inserting the panels, and replacing the molding strip. This fence is to be located so as to run north and south.

The mixtures of pigments are designed on the volume basis; that is, the mixtures, which are directly comparable, contain the same relative volumes of different pigments. For purposes of mixing, however, it is practically necessary to mix the pigments by weight; therefore in the accompanying list of formulas the proportions by weight as well as by volume are given. The pigments are to be mixed with raw oil to which is to be added a known

quantity of lead and manganese as linonates; sufficient oil is to be used to give a standard viscosity.

The Committee has received donations of a sufficient quantity of the following pigments:

Number.	Pigment.
101.....	White Lead, Dutch Process.
102.....	White Lead, Carter's Process.
103.....	White Lead, Acme White Lead Company.
104.....	Zinc Oxide, French Process.
105.....	Zinc Oxide, American Process.
106.....	Sublimed Lead.
107.....	Zinc Lead White.
108.....	Silica.
109.....	Asbestine.
110.....	China Clay.
111.....	Calcium Carbonate.
112.....	Calcium Sulphate.
113.....	Barytes.

Since silica, asbestine, China clay, calcium carbonate, calcium sulphate and barytes are never used alone as pigments for oil paints, the number of single pigment paints is reduced to seven.

The following list gives the mixtures of pigments to be tested:

Number.	PRIMARY PIGMENTS.
101.....	White Lead, Dutch Process.
102.....	White Lead, Carter's Process
103.....	White Lead, Acme White Lead Company.
104.....	Zinc Oxide, French Process.
105.....	Zinc Oxide, American Process.
106.....	Sublimed Lead.
107.....	Zinc Lead White.

BINARY COMPOSITION.*		
Number.	Percentage by Volume.	Percentage by Weight.
201.....	White Lead 80, Zinc Oxide 20	83 17
202.....	" " 80, Sublimed Lead 20	81 19
203.....	" " 80, Silica 20	91 9
204.....	" " 80, Asbestine 20	90 10
205.....	" " 80, China Clay 20	91 9
206.....	" " 80, Calcium Carbonate 20	91 9
207.....	" " 80, Calcium Sulphate 20	92 8
208.....	" " 80, Barytes 20	86 14

*Unless otherwise specified, the zinc oxide used shall be American Process.

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BINARY COMPOSITION. (Continued.)			
Number.	Percentage by Volume.		Percentage by Weight.
209.....	White Lead	50, Zinc Oxide 50*	55 45
210.....	" "	50, Sublimed Lead 50	51 49
211.....	" "	50, Silica 50	71 29
212.....	" "	50, Asbestine 50	70 30
213.....	" "	50, China Clay 50	71 29
214.....	" "	50, Calcium Carbonate 50	71 29
215.....	" "	50, Calcium Sulphate 50	74 26
216.....	" "	50, Barytes 50	61 39
217.....	" "	60, Zinc Oxide 40	64 36
218.....	" "	60, Zinc Oxide 40*	64 36
219.....	" "	60, Sublimed Lead 40	61 39
220.....	Zinc Oxide	50, White Lead 50	45 55
221.....	" "	50, Sublimed Lead 50	46 54
222.....	" "	50, Silica 50	67 33
223.....	" "	50, Asbestine 50	66 34
224.....	" "	50, China Clay 50	67 33
225.....	" "	50, Calcium Carbonate 50	67 33
226.....	" "	50, Calcium Sulphate 50	70 30
227.....	" "	50, Barytes 50	56 44
228.....	Subl. Lead	50, Silica 50	71 29
229.....	" "	50, Asbestine 50	69 31
230.....	" "	50, China Clay 50	71 29
231.....	" "	50, Calcium Carbonate 50	71 29
232.....	" "	50, Calcium Sulphate 50	72 28
233.....	" "	50, Barytes 50	60 40
234.....	Zinc Oxide	60, White Lead 40	55 45
235.....	Zinc Oxide*	60, White Lead 40	55 45

TERNARY COMPOSITION.			
Number.	Volume.		Percentage by Weight.
301.....	White Lead $\frac{1}{2}$	Zinc Oxide $\frac{1}{2}$, Sublimed Lead $\frac{1}{2}$	36-29-35
302.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Silica $\frac{1}{2}$	45-37-18
303.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Asbestine $\frac{1}{2}$	44-36-20
304.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, China Clay $\frac{1}{2}$	45-37-18
305.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Calcium Carbonate $\frac{1}{2}$	45-37-18
306.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Calcium Sulphate $\frac{1}{2}$	46-38-16
307.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Barytes $\frac{1}{2}$	40-33-27
308.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Sublimed Lead $\frac{1}{2}$	53-25-22
309.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Silica $\frac{1}{2}$	62-25-13
310.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Asbestine $\frac{1}{2}$	62-25-13
311.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, China Clay $\frac{1}{2}$	62-25-13
312.....	" "	" $\frac{1}{2}$, " $\frac{1}{2}$, Calcium Carbonate $\frac{1}{2}$	62-25-13

* French Zinc Oxide.

DISCUSSION

Mr. Rinald. **MR. C. D. RINALD.**—Every year thus far our Committee on Preservative Coatings has presented us with one or more sub-committees. Their activity serves to render its reports more valuable and, it must be admitted, harder to digest, because more complicated.

This year I have been pleasantly surprised by the arrival of a Sub-Committee on Vehicles. Too much exclusive attention has been given thus far to pigments, the solid constituents of paint. True, they offer a tangible hold to the chemist for conclusions based on analysis and on those ingenious tests described in our previous Proceedings. When we turn to the liquid constituents of paint, the so-called vehicle, which often consists of a mixture of various liquids and solutions, chemistry is not equally available.

Without any desire to criticise, or even discuss, the substance of to-day's report on vehicles, I simply want to suggest that such tests will prove more useful if conducted along physical, perhaps even empirical, rather than chemical lines. Paint makers will understand me, because it is by such tests that they have years ago found uses for such unorthodox oils as coal oil, corn oil, cottonseed oil, tung oil, fish oil, etc. All these oils, if judiciously used, perform important functions and lead to results which cannot be obtained otherwise. I think I can make this clear to all of you who are paint users, by reminding you of the saponifying and oxidizing action of red lead upon linseed oil, as shown by their mixture hardening in the can over night. The practice formerly was to mix only enough of both each morning to last during the day. Now you buy your red lead paint ready mixed in barrels, and your chemists find that it answers their tests for pure red lead and pure linseed oil. I have also been assured that it gives no trouble from settling,—i. e., hard sediment *does not* form in the bottom of the barrels,—and that it dries as hard and protects as much as heretofore. This shows how important physical advantages may be

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TERNARY COMPOSITION. (Continued.)

Number.	Volume.	Percentage by Weight.
357.....	White Lead $\frac{1}{2}$, Subl. Lead $\frac{1}{2}$, Calcium Sulphate $\frac{1}{2}$...	60-29-11
358.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Barytes $\frac{1}{2}$	55-27-18
359.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Silica $\frac{1}{2}$	30-58-12
360.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Asbestine $\frac{1}{2}$	30-58-12
361.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, China Clay $\frac{1}{2}$	30-58-12
362.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Calcium Carbonate $\frac{1}{2}$	30-58-12
363.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Calcium Sulphate $\frac{1}{2}$...	30-58-12
364.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Barytes $\frac{1}{2}$	28-52-20
365.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Silica $\frac{1}{2}$	36-35-29
366.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Asbestine $\frac{1}{2}$	36-35-29
367.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, China Clay $\frac{1}{2}$	36-35-29
368.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Calcium Carbonate $\frac{1}{2}$	36-35-29
369.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Calcium Sulphate $\frac{1}{2}$...	38-36-26
370.....	" " $\frac{1}{2}$, " " $\frac{1}{2}$, Barytes $\frac{1}{2}$	30-29-41

QUATERNARY COMPOSITION.

401.	Volume.	Weight.	404	Volume.	Weight.
White Lead.....	$\frac{1}{2}$	31	White Lead.....	$\frac{1}{2}$	31
Zinc Oxide.....	$\frac{1}{2}$	25	Zinc Oxide.....	$\frac{1}{2}$	25
Subl. Lead.....	$\frac{1}{2}$	30	Subl. Lead.....	$\frac{1}{2}$	30
Silica.....	$\frac{1}{2}$	14	Calc. Carb.....	$\frac{1}{2}$	14
402	Volume.	Weight.	405	Volume.	Weight.
White Lead.....	$\frac{1}{2}$	31	White Lead.....	$\frac{1}{2}$	31
Zinc Oxide.....	$\frac{1}{2}$	25	Zinc Oxide.....	$\frac{1}{2}$	26
Subl. Lead.....	$\frac{1}{2}$	30	Subl. Lead.....	$\frac{1}{2}$	31
Asbestine.....	$\frac{1}{2}$	14	Calc. Sulph.....	$\frac{1}{2}$	12
403	Volume.	Weight.	406	Volume.	Weight.
White Lead.....	$\frac{1}{2}$	31	White Lead.....	$\frac{1}{2}$	29
Zinc Oxide.....	$\frac{1}{2}$	25	Zinc Oxide.....	$\frac{1}{2}$	24
Subl. Lead.....	$\frac{1}{2}$	30	Subl. Lead.....	$\frac{1}{2}$	28
China Clay.....	$\frac{1}{2}$	14	Barytes.....	$\frac{1}{2}$	19

The Committee has received as donations sufficient linseed oil for grinding these pigments and cans for keeping them. The paints are being ground in the laboratory of Pratt Institute of Brooklyn under the direction of Professor Rogers. Offers have been made by two railroads to have the paints applied in their shops.

Respectfully submitted on behalf of the Sub-Committee,

P. H. WALKER,
Chairman, Sub-Committee J.

DISCUSSION

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obtained by the judicious admixture of oils, which conform to Mr. Rinald. none of the rules laid down by the chemist, who quite correctly finds each single one of them unfit to act as a paint oil. All of which seems to me to indicate that it would be most important to study the action of various oils and solutions upon each other when combined into a vehicle, and the reactions between the latter and the pigment in the paint. I have spent a good deal of time examining the paint fence at Ventnor and I am not the only one here who thinks that some of those pigments which theoretically are "inhibitors" show up worse than others termed "accelerators." All of them were ground alike in linseed oil. I should like to have our Committee on Preservative Coatings, in future tests, consider the inclusion of pigments ground in vehicles specially prepared for them, such as the Sub-Committees on Varnish and on Vehicles ought to be able to suggest.

REPORT OF COMMITTEE D-1
ON
PRESERVATIVE COATINGS FOR STRUCTURAL
MATERIALS.

Owing to the early meeting of the Society last year, Committee D-1 did not render any report and therefore the present report shows the progress made since the last report of this committee, which appears in the Proceedings for 1911, page 173. The committee has held four meetings since July 1, 1911.

Much against the wishes of the committee, Mr. S. S. Voorhees, who had been chairman for about ten years, insisted on being relieved and after unsuccessful efforts to cause him to change his mind his resignation as chairman was accepted at a meeting held November 26, 1912. The committee, on accepting Mr. Voorhees' resignation, unanimously adopted the following resolution:

"Committee E, now Committee D-1, was appointed before the Fifth Annual Meeting of the American Society for Testing Materials and made its first report to the Society in 1903. Practically ten years have passed since this committee was organized. We believe that a large part of the success of the committee's work has been due to the interest, good judgment, and the effective personality of its chairman, Mr. S. S. Voorhees, who, after ten years of labor, feels called upon to resign the post of chairman.

"It is with great regret that Committee D-1 accepts Mr. Voorhees' resignation, and in doing so, desires to express to Mr. Voorhees, on behalf of the committee and its members, individually, the high regard in which he is held, and to pledge to him a continuance of this regard, and an earnest hope for his future welfare and happiness.

"*Therefore, be it Resolved*, That a copy of the above declaration be inserted in the minutes of this committee, and that a copy of this preamble and resolution be suitably engrossed and presented to Mr. Voorhees."

Committee D-1 now has fifty-three members and that a large majority of them take active interest in the work done is shown by the fact that at the meeting held on April 18, 1913, in Washington, twenty-eight members attended, and among those

who were unable to attend were a number who have done a great deal of work.

This committee has been very conservative in presenting specifications and at this meeting, after being in existence for ten years, submits its first recommendation of a specification for adoption by the Society, this being a specification for raw linseed oil made from North American seed. The data upon which this specification is based have been collected by the committee during several years of careful and painstaking work.

There are also presented at this meeting certain "Proposed Standard Definitions of Terms used in Paint Specifications," with a recommendation that they be adopted by the Society.

The work of the old Sub-Committee J on White Paint Tests having been completed with the installation of the Arlington test fence, this sub-committee has been discharged and a new Sub-Committee J on Inspection of the Arlington Test Fence has been created.

The committee has adopted the following rules for the guidance of its sub-committees:

1. Each sub-committee shall elect a secretary, who shall keep minutes of its meetings, etc., assist the chairman of the sub-committee in correspondence, notifying the members of meetings, etc., and confer with the Secretary of Committee D-1, in the preparation of reports.
2. All records of sub-committees and its officers shall ultimately be transmitted to the Secretary of Committee D-1, for filing.
3. No expense shall be incurred by any sub-committee except for postage or stationery, unless previously authorized by the Advisory Committee. Statements of the expenses of sub-committees shall be sent to the Secretary of Committee D-1, for payment quarterly dating from July 1.
4. These rules shall go into effect at once.

In addition to the work on hand it is expected to take up the study of volatile thinners other than turpentine, at an early date.

Sub-Committee A, the Advisory Committee, has held three meetings; but as this sub-committee simply acts when it is not advisable to call a meeting of the whole committee, it has no formal report to render.

Detailed reports are appended from Sub-Committee B on the Inspection of the Havre de Grace Bridge, Sub-Committee C on the Testing of Paint Vehicles, Sub-Committee D on the

Inspection of Steel Plates at Atlantic City, Sub-Committee E on Linseed Oil, Sub-Committee F on Definitions of Terms used in Paint Specifications, and the old Sub-Committee J on Testing White Paints. Sub-Committee G on the Influence of Pigments on Corrosion, Sub-Committee H on Methods of Analysis of Paint Materials, Sub-Committee I on Varnish, and the new Sub-Committee J on Inspection of the Arlington Test Fence, have no formal reports to present. The chairman of Sub-Committee G on the Influence of Pigments on Corrosion, recommends that this sub-committee be discharged, but no action has been taken on this recommendation.

The committee is indebted to various experts for valuable laboratory work. This is especially the case in the work of Sub-Committees C and J. In the report of Sub-Committee C the names of those making the tests appear. This is not the case in the report of Sub-Committee J, and the committee therefore takes this occasion to express its thanks to F. W. Smither, J. H. Bower, and G. C. Schmidt of the Bureau of Chemistry, and A. N. Finn of the Bureau of Standards, for the very complete series of analyses of the pigments; to A. C. Belden of the National Lead Co. for the classification tests on the pigments; and to B. J. Howard of the Bureau of Chemistry for the complete series of microphotographs.

The detailed reports of the various sub-committees follow this report.

Respectfully submitted on behalf of the committee,

PERCY H. WALKER,
Chairman.

G. W. THOMPSON,
Secretary.

REPORT OF SUB-COMMITTEE B ON
INSPECTION OF THE HAVRE DE GRACE BRIDGE.

Growing out of reports of several sub-committees in December, 1904, previously appointed to study and devise methods with recommendations for carrying these out, the Havre de Grace Bridge tests were inaugurated in the summer and autumn of 1906 through the courtesy of the Pennsylvania Railroad Co. in placing at the disposal of the committee such part of their new bridge over the Susquehanna River as might be determined necessary.

To communications addressed to prominent paint manufacturers of the country stating the opportunity offered for such a comparative service test never previously undertaken under like circumstances, replies were received from sixteen expressing their preparedness to enter the trial test. The expenses of this test were assumed by the several competitors under an estimate of cost by the committee and a *pro rata* assessment.

LIST OF CONTRIBUTORS.

Name.	Address.	No. of Paints furnished.
Devoe & Reynolds.....	New York City, N. Y.....	2
Eagle White Lead Co.....	Cincinnati, Ohio.....	1
Felton, Sybley & Co.....	Philadelphia, Pa.....	1
Frazier Paint Company.....	Detroit, Mich.....	1
Harrison Brothers.....	Philadelphia, Pa.....	1
Lowe Brothers.....	Dayton, Ohio.....	1
John Lucas & Co.....	Philadelphia, Pa.....	1
John W. Masury & Son.....	Brooklyn, N. Y.....	1
C. L. Miller.....	New York City, N. Y.....	1
National Lead Company.....	Brooklyn, N. Y.....	1
Patton Paint Company.....	Milwaukee, Wis.....	1
Rinalds Brothers.....	Philadelphia, Pa.....	1
The Sherwin Williams Co.....	Cleveland, Ohio.....	3
Toch Brothers.....	New York City, N. Y.....	1
Wadsworth, Howland Co.....	Boston, Mass.....	1
The A. Wilhelm Co.....	Reading, Pa.....	1

The steel plates were contributed by the United States Steel Co.

The actual application of each of the nineteen paints submitted by sixteen different manufacturers, was made both on steel plate panels, three each, at the several spreading rates of 600, 900 and 1200 sq. ft. per gallon of paint, as well as on sections of the bridge proper, where very naturally the spreading rate could not be as absolutely controlled as in the case of the plate panels, but where the natural spreading rate would most probably apply. Neither in the case of the bridge sections was the metal surface as specially prepared as were the plate panels, though undoubtedly the structure was in better condition for field painting than is usually the case, effort being made to clean the structure as well as possible before applying the paint.

Reports have been made from year to year on existing plate-panel conditions—of late years more in detail than was possible at the earlier test periods and attention has been called at various times to certain of the paints on the bridge sections at that time warranting special notice.

The last inspection of the Havre de Grace Bridge was held on Friday, May 3, 1912, with a very full attendance of the inspection committee and a number of other members of Committee D-1, the day being devoted to special examination of the panels under the same schedule of marking used on previous inspections with the customary divisions, namely:

- A.....Chalking.
- B.....Checking, Cracking, Alligatoring, Etc.
- C.....General Surface Conditions.

with the following marking for each:

Excellent.....	10 to 8
Good.....	8 to 6
Fair.....	6 to 4
Poor.....	4 to 2
Failure.....	2 to 0

The results of this inspection are given in Table I, showing ratings by nine individual inspectors or pairs of inspectors, for each of the three different rates of spreading of each paint, and in Table II, showing average rating of these same nine inspectors of each paint, covering all rates of spreading. These

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TABLE I.—INSPECTION OF GENERAL SURFACE CONDITIONS.

600-Sq-Ft. SPREADING RATE.

Paint No.	Aiken and Force.	McNaughton and Thompson.	Voorhees.	Gibboney.	Polk.	Tassin.	White.	Lawrie.	Sabin.	Average.
1	7.0		5.0	4.7	9.0	8.0	8.0	7.0	10.0	7.3
2	6.0		3.0	5.3	0.0	0.0	5.0	5.0	7.0	3.9
3	8.0		7.0	7.0	8.0	7.0	6.5	7.0	10.0	7.5
4	8.0		4.0	7.0	8.5	4.0	5.0	8.0	9.0	6.7
5	9.0		5.0	8.0	9.5	8.0	5.0	7.0	10.0	7.7
6	8.5	McNaughton and Thompson averaged all rates of spreading (See Table II)	6.0	8.0	9.5	8.0	5.0	9.0	10.0	8.0
7	8.0		4.0	8.0	7.0	4.0	6.0	7.0	10.0	6.8
8	8.5		4.0	8.0	7.0	7.0	7.5	7.0	9.0	7.3
9	7.0		4.0	4.0	6.0	0.0	5.0	5.0	9.5	5.1
10	8.5		8.0	10.0	9.5	8.0	7.0	7.0	10.0	8.5
11	9.0		8.0	10.0	9.5	8.0	8.0	9.0	10.0	8.9
12	8.5		8.0	8.3	9.0	6.0	9.0	8.0	10.0	8.3
13	8.0		5.0	6.0	6.9	3.0	6.0	6.0	10.0	6.3
14	9.0		7.0	10.0	9.0	6.0	9.0	8.0	10.0	8.5
15	1.0		0.0	0.0	0.0	0.0	0.0	3.0	5.0	1.1
16	8.5		6.0	8.0	8.0	5.0	7.0	8.0	9.2	7.5
17	8.0		7.0	8.0	8.0	2.0	7.0	7.0	8.8	7.0
18	9.0		7.0	9.0	9.0	5.0	8.0	8.0	10.0	8.1
19	6.0		5.0	5.0	5.0	0.0	6.7	7.0	8.8	5.4

900-Sq-Ft. SPREADING RATE.

1	6.0		6.0	5.0	8.0	8.0	7.5	8.0	7.0	7.0
2	2.0		0.0	2.0	2.0	0.0	2.0	0.0	3.0	1.4
3	7.0		7.0	6.0	6.0	4.0	6.0	6.0	9.5	6.4
4	7.0		3.0	6.0	8.0	3.0	4.0	8.0	8.0	5.9
5	8.5		5.0	7.5	9.0	8.0	5.0	8.0	10.0	7.6
6	8.0	McNaughton and Thompson averaged all rates of spreading (See Table II)	6.0	9.0	9.0	8.0	6.0	8.0	10.0	8.0
7	7.5		4.0	6.0	4.0	3.0	5.0	6.0	9.0	5.6
8	8.5		4.0	6.5	6.0	7.0	6.0	7.0	9.0	6.8
9	5.0		3.0	2.0	2.0	2.0	4.0	4.0	8.5	3.8
10	7.5		8.0	10.0	8.5	8.0	7.0	7.0	10.0	8.3
11	9.0		8.0	10.0	9.5	8.0	8.0	9.0	10.0	9.0
12	7.5		7.5	8.0	6.0	3.0	8.0	7.0	10.0	7.1
13	7.0		3.0	4.0	4.0	1.0	4.0	4.0	8.0	4.4
14	8.5		6.5	8.5	8.5	5.0	7.0	7.0	9.5	7.8
15	0.0		0.0	0.0	0.0	0.0	0.0	2.0	4.0	0.8
16	8.0		5.0	8.0	6.0	4.0	6.0	7.0	9.2	6.7
17	7.0		6.0	4.5	7.0	3.0	5.0	6.0	7.5	5.8
18	8.0		6.0	9.0	8.5	6.0	8.0	7.0	9.5	7.8
19	7.0		6.0	4.0	8.0	0.0	7.0	7.0	8.8	6.7

1200-Sq-Ft. SPREADING RATE.

1	6.5		6.0	4.7	8.0	6.0	7.0	8.0	7.0	6.7
2	0.0		0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0
3	5.0		3.0	2.0	4.0	2.0	4.0	5.0	8.0	4.1
4	6.0		3.0	4.0	6.0	0.0	4.0	8.0	7.0	4.8
5	6.5		5.0	7.0	7.0	6.0	4.0	8.0	9.0	6.6
6	7.0	McNaughton and Thompson averaged all rates of spreading (See Table II)	6.0	9.0	9.0	8.0	6.0	8.0	10.0	7.9
7	2.0		2.0	2.0	2.0	0.0	2.0	4.0	5.0	2.4
8	8.0		4.0	5.0	4.0	6.0	6.0	7.0	8.0	6.0
9	0.0		0.0	0.0	0.0	0.0	2.0	2.0	4.0	1.0
10	7.0		7.0	10.0	8.0	8.0	7.0	7.0	10.0	8.0
11	8.0		8.0	10.0	9.5	8.0	8.0	9.0	10.0	8.8
12	5.0		4.0	6.0	4.0	2.0	6.0	6.0	8.8	5.2
13	4.0		2.0	4.0	0.0	0.0	3.0	5.0	6.0	3.0
14	7.5		6.0	8.0	8.0	4.0	6.0	6.0	9.5	7.0
15	2.0		1.0	0.0	0.0	0.0	1.0	4.0	6.5	1.8
16	6.0		4.0	7.0	4.0	3.0	5.0	5.0	8.0	5.2
17	7.0		6.0	5.0	7.0	7.0	6.0	7.0	7.0	6.8
18	7.0		6.0	8.0	7.0	5.0	6.0	5.0	8.0	6.5
19	7.0		6.0	4.0	7.0	0.0	5.0	7.0	8.0	5.5

ON INSPECTION OF HAVRE DE GRACE BRIDGE. 335

TABLE II.—INSPECTION OF GENERAL SURFACE CONDITIONS.

COMPILED AVERAGE OF ALL RATES—600, 900, 1200 Sq. Ft.

Paint No.	Aiken and Force.	McNaughton and Thompson.	Voorhees.	Gibboney.	Polk.	Tassin.	White.	Lawrie.	Sabin.	Average.
1	6.5	7.0	5.7	4.8	8.3	7.3	7.5	7.7	8.0	7.0
2	2.7	0.0	1.0	2.4	0.7	0.0	3.0	1.7	3.3	1.6
3	6.7	8.0	5.7	5.0	6.0	4.3	5.5	6.0	9.2	6.3
4	7.0	6.0	3.3	5.7	7.5	2.3	4.3	8.0	8.0	5.8
5	8.0	9.0	5.0	7.5	8.3	7.3	4.7	7.7	9.7	7.3
6	7.8	9.0	6.0	8.7	9.2	8.0	5.7	8.3	10.0	8.0
7	5.7	3.3	3.3	5.3	4.3	2.3	4.3	5.7	8.0	5.1
8	8.3	8.0	4.0	6.5	5.7	6.7	6.5	7.0	8.7	6.7
9	4.0	5.0	2.3	2.0	2.7	0.7	3.7	3.7	7.3	3.5
10	7.7	9.0	7.8	10.0	8.7	8.0	7.0	7.0	10.0	8.3
11	8.7	9.0	8.0	10.0	9.5	8.0	8.0	9.0	10.0	8.9
12	7.0	7.0	6.5	7.4	6.3	3.7	7.7	7.0	9.6	6.9
13	6.7	5.0	3.3	4.7	3.3	1.3	4.3	5.0	8.0	4.6
14	8.3	8.0	6.5	8.8	8.5	5.0	7.3	7.0	9.7	7.7
15	1.0	0.0	0.3	0.0	0.0	0.0	0.3	3.0	5.2	1.2
16	7.5	7.0	5.0	7.8	6.0	4.0	6.0	6.7	8.7	6.5
17	7.3	6.0	6.3	5.8	7.3	4.0	6.0	6.7	7.8	6.5
18	8.0	8.0	6.3	8.7	8.2	5.3	7.3	6.7	9.2	7.5
19	6.7	7.0	5.7	4.3	6.7	0.0	6.2	7.0	8.5	5.9

TABLE III.—CLASSIFICATION FROM TABLES I AND II.

Paint No.	Panel Spreading Rate, sq. ft. per gal.			Average.	Bridge Sections.
	600	900	1200		
1	II	II	III	II	II
2	V	V	V	V	V
3	II	III	V	III	II
4	III	IV	V	IV	IV
5	II	II	III	II	II
6	I	I	I	I	I
7	III	IV	V	IV	IV
8	II	III	III	III	II
9	IV	V	V	V	IV
10	I	I	I	I	I
11	I	I	I	I	I
12	I	II	IV	III	II
13	III	V	V	V	IV
14	I	II	II	II	II
15	V	V	V	V	V
16	II	III	IV	III	II
17	II	IV	III	III	II
18	I	II	III	II	II
19	IV	III	IV	IV	IV

DESCRIPTION OF CLASSES.

Class.	Averaging.	600 sq. ft.	900 sq. ft.	1200 sq. ft.	Description.
I	8-9	8.4	8.4	8.2	Quite excellent
II	7-8	7.4	7.5	7.0	Quite good
III	6-7	6.6	6.6	6.1	Good
IV	5-6	5.3	5.8	5.3	Fair
V	below 5	Poor or failed

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TABLE IV.—SUMMARY FROM TABLE III, SHOWING THE PAINTS FALLING IN THE VARIOUS CLASSES.

Class.	Panel Spreading Rate, sq. ft. per gal.			Average.	Bridge Sections.
	600	900	1200		
I	6, 10, 11, 12, 14, 18.	6, 10, 11.	6, 10, 11.	6, 10, 11.	6, 10, 11.
II	1, 3, 5, 8, 16, 17.	1, 5, 12, 14, 18.	14.	1, 5, 14, 18.	1, 3, 5, 8, 12, 14, 16, 17, 18.
III	4, 7, 13.	3, 8, 16, 19.	1, 5, 8, 17, 18.	3, 8, 12, 16, 17.	.....
IV	9, 19.	4, 7, 17.	12, 16, 19.	4, 7, 19.	4, 7, 9, 13, 19.
V	2, 15.	2, 9, 13, 15.	2, 3, 4, 7, 9, 13, 15.	2, 9, 13, 15.	2, 15.

tables cover only division C (general surface conditions) such being considered at this time the most important point as defining the protective value of the paints. Table III shows a classification of the data in Tables I and II. Table IV is a summary prepared from Table III.

In analyzing these "general surface condition" averages of the several rates of spreading, the results have been divided arbitrarily into five classes, as follows:

Class I, including paints with average markings between 8.0 and 9.0; quite excellent.

Class II, including paints with average markings between 7.0 and 8.0; quite good.

Class III, including paints with average markings between 6.0 and 7.0; good.

Class IV, including paints with average markings between 5.0 and 6.0; fair.

Class V, including paints with average markings below 5.0; poor or failed.

We find under the 600-sq.-ft. rate of spreading:

Six paints (Nos. 6, 10, 11, 12, 14 and 18) with an average of 8.4, designated as quite excellent in Class I;

Six paints (Nos. 1, 3, 5, 8, 16 and 17) with an average of 7.4, designated as quite good in Class II;

Three paints (Nos. 4, 7 and 13) with an average of 6.6, designated as good in Class III;

Two paints (Nos. 9 and 19) with an average of 5.3, designated as fair in Class IV; and
 Two paints (Nos. 2 and 15) which have failed.

We find under the 900-sq-ft. rate of spreading:

Three paints (Nos. 6, 10 and 11) with an average of 8.4, designated as quite excellent in Class I;
 Five paints (Nos. 1, 5, 12, 14 and 18) with an average of 7.5, designated as quite good in Class II;
 Four paints (Nos. 3, 8, 16 and 19) with an average of 6.6, designated as good in Class III;
 Three paints (Nos. 4, 7 and 17) with an average of 5.8, designated as fair in Class IV; and
 Four paints (Nos. 2, 9, 13 and 15) which are poor (Nos. 9 and 13) or have failed (Nos. 2 and 15)—these last two being those marked as failing under the 600-sq-ft. spreading rate.

We find under the 1200-sq-ft. rate of spreading:

Three paints (Nos. 6, 10 and 11) with an average of 8.2, designated as quite excellent in Class I;
 One paint (No. 14) with an average of 7.0, designated as quite good in Class II;
 Five paints (Nos. 1, 5, 8, 17 and 18) with an average of 6.1, designated as good in Class III;
 Three paints (Nos. 12, 16 and 19) with an average of 5.3, designated as fair in Class IV; and
 Seven paints (Nos. 2, 3, 4, 7, 9, 13 and 15) which are marked poor (two), or to have failed (five). Two of these failed on previous spreading rates, two are noted in Class III and one in Class IV, even under the 600-sq-ft. spreading rate.

Note that the three paints in Class I under the 900 and 1200-sq-ft. rate of spreading are identical with three of the six in this same class under the 600-sq-ft. rate. Note also that the other three in Class I under the 600-sq-ft. rate drop into Class II under the 900-sq-ft. rate, and that only one of these barely maintains its standing in this class under the 1200-sq-ft. rate, the other two dropping, one into Class III and the other into Class IV.

Note that of the six paints originally in Class II under the 600-sq-ft. rate of spreading, only two maintain this standing

under the 900-sq-ft. rate, and none maintain such standing under the 1200-sq-ft. rate.

Note that of the three paints originally in Class III under the 600-sq-ft. rate of spreading, none maintains this standing at the 900-sq-ft. rate and all disappear as poor or failures under the 1200-sq-ft. rate.

Note that of the two paints originally in Class IV under the 600-sq-ft. rate of spreading, one has no standing in either the 900 or 1200-sq-ft. rate, but the other ascends to Class III under the 900-sq-ft. rate, which is rather anomalous, but tends to show that its natural spreading rate is apparently 900 sq. ft. per gallon and not 600 sq. ft. as the bulk of the other paints show, although it may be noted here that the three paints which appear in Class I under all three rates of spreading are apparently equally without any distinctive natural spreading rate.

The inspection of the bridge proper, from which conclusions are hereafter drawn relative to the protective value of the different paints thereon, was made Friday, May 24, by the Chairman, assisted by Messrs. Anderson Polk and Wirt Tassin, both of the inspection committee.

Three paints (Nos. 6, 10 and 11) in Class I, under each of the separate spreading rates, may each well be designated as excellent on the bridge sections, though they vary slightly in degree of merit. What differentiates these paints from all others under observation is the fact that while all the other paints except one furnish their best protection, such as it is, under the 600-sq-ft. rate of spreading and are generally markedly less effective under the thinner film rate, these three show such slight variation under different rates of application as to appear equally protective under either. Further, these three paints show more concordant results between the test panels and the bridge sections than any others.

This is not to be interpreted as meaning that there is no evidence of failure of these paints on the bridge proper, for there is some deterioration taking place; but the protection as a whole is to-day excellent and concordant with the panel observations as being very nearly identical in showing.

Nine paints, three (Nos. 12, 14 and 18) being of Class I, under the 600-sq-ft. spreading rate—referred to in our pre-

vious analysis of the panel inspection as falling into the next class under the 900-sq-ft. rate—and six paints (Nos. 1, 3, 5, 8, 16 and 17), originally of Class II, under the 600-sq-ft. rate, deserve possibly a higher rating than Class II on the bridge proper, since the protection furnished, while failing here and there as have practically all the paints in spots,—for which there may be more or less local explanation,—is generally effective. These nine paints, while not in a class with the three paints specifically referred to above as being in a class by themselves, show upon the bridge proper much better protection generally than on their corresponding best panels, and may be designated on the bridge as very good—certainly superior to the quite good of the panels. In some instances, however, notably paint No. 1, failure may occur at any time, in our opinion, despite the present apparent protection being furnished. Paint No. 1 is apparently in much better condition than close examination shows it to be in reality.

Of the remaining seven paints, paint No. 2, while markedly better than its panels, which have practically entirely failed even at the 600-sq-ft. spreading rate, should be eliminated.

Paint No. 4 needs attention, as it is only furnishing protection about equal to its best panel showing, which is marked good; but the paint on the bridge section, we think, might well be replaced.

Paint No. 7, while appearing in a very low class under the 900-sq-ft. spreading rate and as failed under the 1200-sq-ft. rate in the panels, is in as good condition on the bridge proper as in its panels on the 600-sq-ft. rate, but we think that the life of the paint has about ended on its bridge section.

Paint No. 9 on the bridge proper needs replacement, though it is fully equal to its best panel, which is only fair.

Paint No. 13 on the bridge proper, though better than its best panels, should be replaced.

Paint No. 15, though better than its panels, should be replaced.

Paint No. 19 needs replacing, though only in part at present, being in much better condition than its best panel, which while of low class rating has not been marked as a failure.

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The analyses of all paints were given originally in Vol. VIII of the Proceedings (1908), and can be located therefrom by their numbers as given in this report.¹

As originally contemplated, an attempt has been made to classify the paints from their compositions, but it has been found impracticable so to do.

At our request the Pennsylvania Railroad Co. agreed to having inspection made of this section of the Havre de Grace bridge and the panel tests by themselves and the representatives of other railroads. The reports of these inspections are appended hereto, together with a tabular comparison of these reports and those obtained by our own inspectors.

Respectfully submitted on behalf of the sub-committee,

W. A. AIKEN,
Chairman.

¹Pp. 173 ff. of Vol. VIII, in which the panel numbers correspond to the paint numbers given herewith.

APPENDIX.

REPORTS OF INSPECTION OF HAVRE DE GRACE BRIDGE BY VARIOUS RAILROADS.

PENNSYLVANIA RAILROAD COMPANY.

PHILADELPHIA, April 10, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Referring to our conversation of recent date, I have to advise you that my assistant, Mr. Robert Farnham, Jr., made an examination of the painting of the plates and on the bridge truss proper at the Havre de Grace Bridge, on March 6 last, in company with Mr. Samuel Tobias Wagner, Assistant Engineer, Philadelphia and Reading Railway Co., and reports as follows:

The painting on the plates and trusses were divided into five classes as follows: Excellent, Good, Fair, Poor, and Failure.

For the purpose of rating, the paint on the plates marked "1200 sq. ft." is called A; plates marked "900 sq. ft.," B; plates marked "600 sq. ft.," C, and bridge trusses D.

After a careful examination, I have rated the paints as follows:

Paint No.	A	B	C	D
1.....	Poor	Poor	Fair	Good
2.....	Failure	Failure	Poor	Fair
3.....	Poor	Fair	Good	Fair
4.....	Poor	Poor	Fair	Poor
5.....	Good	Excellent	Excellent	Excellent
6.....	Good	Excellent	Excellent	Excellent
7.....	Failure	Good	Excellent	Good
8.....	Poor	Fair	Fair	Fair
9.....	Failure	Poor	Good	Fair
10.....	Good	Excellent	Excellent	Good to Excellent
11.....	Good	Good	Excellent	Good
12.....	Good	Good	Excellent	Fair to Good
13.....	Failure to Poor	Poor	Good	Fair
14.....	Fair	Fair	Fair to Good	Fair
15.....	Poor	Failure	Failure	Poor
16.....	Poor	Fair	Fair	Good
17.....	Fair	Fair	Good	Good
18.....	Fair	Good	Excellent	Good
19.....	Fair	Fair	Fair	Fair

Yours truly,

H. R. LEONARD,
Engineer of Bridges.

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THE BALTIMORE AND OHIO RAILROAD COMPANY.

BALTIMORE, March 29, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Referring to yours of March 1, requesting that inspection be made of the preservative coatings on the Pennsylvania Railroad Bridge at Havre de Grace, I attach hereto copy of report from Assistant-Engineer-of-Bridges Edwards to Engineer-of-Bridges Bouton, which I trust will serve your purpose.

If consistent, would appreciate it if you will let me know the names of the manufacturers of the paints indicated by numbers, and also the trade names under which the paints are sold.

Yours truly,

F. L. STUART,
Chief Engineer.

March 25, 1913.

MR. W. S. BOUTON,
Engineer of Bridges.

Dear Sir:

In compliance with your instructions, I made an examination on the 24th instant of the condition of the paint on the test sheets, placed on the Pennsylvania Railroad bridge at Havre de Grace by Committee D-1 of the American Society for Testing Materials. In making this inspection I graded each of the test sheets as to general condition, using the standard system of numbering from 0 to 10, which has been adopted by the Committee in their previous reports on these tests. The following table shows the average of these gradings for each of the three rates of application, and also the general average for each paint.

Paint No.	Average Condition, Sheets I.	Average Condition, Sheets II.	Average Condition, Sheets III.	General Average.	Bridge.
1.....	7.0	7.3	7.2	7.1	7.1
2.....	0.0	0.5	3.2	1.3	3.2
3.....	6.8	8.3	8.5	7.8	7.8
4.....	6.5	7.3	7.2	6.9	3.5
5.....	8.3	9.3	9.4	9.0	9.0
6.....	8.9	9.2	8.6	8.9	8.9
7.....	3.2	7.2	8.8	6.3	6.3
8.....	7.5	8.2	8.9	8.0	8.0
9.....	0.2	3.5	4.7	2.7	2.7
10.....	9.0	9.5	9.5	9.3	9.3
11.....	9.5	9.5	9.5	9.5	9.5
12.....	7.8	8.8	8.8	8.4	8.4
13.....	2.3	4.7	8.2	5.1	8.2
14.....	8.0	8.5	9.0	8.5	8.5
15.....	4.3	0.7	0.8	2.1	2.1
16.....	6.1	8.6	8.8	7.7	7.5
17.....	7.3	7.0	7.5	7.3	7.3
18.....	6.8	7.0	8.2	7.4	7.4
19.....	7.3	7.3	7.1	7.1	7.0

The general condition of the paint on the bridge is about the same as that on the test sheets, for Paints Nos. 1, 3, 6, 10, 12, 14, 17 and 18.

For Paint No. 2 the general condition on the bridge is about the same as that represented by Sheets III, and the rust is showing through the paint very generally.

The general condition of Paint No. 4 on the bridge is quite poor, being only about 50 per cent as good as shown by the test sheets.

Paint No. 5 is in slightly better average condition on the bridge than on the test sheets, but the correspondence between the two is very close.

The condition of Paint No. 7 on the bridge is very uneven, being excellent in places and almost a complete failure elsewhere. The general average is about the same as on the test sheets.

The condition of Paint No. 8 on the bridge is not quite so good as that on the test sheets. On horizontal surfaces the paint is practically dead and the metal exposed and rusted.

Paint No. 9 is entirely gone from the bridge in places, but is in fair condition on protected surfaces. The test sheets indicate that this paint is just about at the point of complete failure where exposed.

The condition of Paint No. 11 on the bridge, while excellent, is not quite so good as shown on the test sheets.

The condition of Paint No. 13 on the bridge will average about the same as on Sheets III, and the better one of Sheets II. There is no considerable area where the conditions are as bad as indicated by Sheets I.

The condition of Paint No. 15 on the bridge is poor, but is considerably better than that shown on the test sheets, except over limited areas.

The condition of Paints Nos. 16 and 19 on the bridge is slightly worse than that shown on the test sheets.

Yours truly,

W. R. EDWARDS.
Asst. Engineer of Bridges.

PHILADELPHIA AND READING RAILWAY COMPANY.

PHILADELPHIA, March 7, 1913.

MR. W. A. AIKEN,

Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Referring to our recent interview in which you asked me to have someone in this Company examine the paints on the Susquehanna River Bridge at Havre de Grace, Pennsylvania Railroad, in connection with the work of the American Society for Testing Materials, I beg to advise you that I turned this matter over to Assistant-Engineer Wagner for his attention, and he advises me that he has been in consultation with you and that you asked him to prepare a report covering this matter.

I am handing you this report herewith, and trust that you will find it satisfactory.

Yours truly,

W. HUNTER,
Chief Engineer.

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March 7, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Complying with your recent request, I visited the Susquehanna River Bridge of the Pennsylvania Railroad, at Havre de Grace, yesterday, accompanied by Mr. Robert Farnham, Jr., Assistant Engineer, Pennsylvania Railroad Co., and made an examination of the painting of the panels of plates and the paint on the bridge trusses proper.

Separate notice was taken of the following specimens under each number of the paint as applied:

- A. Panel (plate) marked 1200 sq. ft.
- B. Panel (plate) marked 900 "
- C. Panel (plate) marked 600 "
- D. Bridge trusses.

As to the character of the paint at the present time, I have endeavored to describe it under the following headings:

Excellent, Good, Fair, Poor, and Failure.

According to my best judgment, the ratings would be as follows:

Paint No.	A	B	C	D
1.....	Poor	Poor	Fair	Good
2.....	Failure	Failure	Poor	Fair
3.....	Poor	Fair	Good	Fair
4.....	Poor	Poor	Fair	Poor
5.....	Good	Good	Excellent	Excellent
6.....	Good	Excellent	Excellent	Excellent
7.....	Failure	Good	Excellent	Good
8.....	Poor	Fair	Fair	Fair
9.....	Failure	Poor	Good	Fair
10.....	Good	Good	Excellent	Good
11.....	Good	Good	Excellent	Good
12.....	Good	Good	Excellent	Fairly Good
13.....	Poor to Failure	Fair	Good	Fair
14.....	Fair	Fair	Fair	Fair
15.....	Poor	Failure	Failure	Poor
16.....	Poor	Fair	Fair	Good
17.....	Fair	Fair	Good	Good
18.....	Fair	Good	Excellent	Good
19.....	Fair	Fair	Fair	Fair

The records under heads A, B and C covered the average of three plates of A and C, respectively, and but two plates of B. One plate of B of each paint had been removed from the bridge.

Respectfully submitted,

SAMUEL TOBIAS WAGNER,
Assistant Engineer.

ON INSPECTION OF HAVRE DE GRACE BRIDGE. 345

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD
COMPANY.

NEW YORK, April 5, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

On the 1st instant we made the examination that you requested of the paint tests on the Havre de Grace bridge.

The following schedule gives the averages of our marks as representing the general surface conditions; these apply to the test plates only:

Paint No.	Spreading Rate, sq. ft. per gal.			Average.
	1200	900	600	
1.....	5.0	5.0	5.5	5.2
2.....	1.5	2.5	4.0	2.7
3.....	5.5	8.0	8.0	7.2
4.....	5.0	6.0	7.0	6.0
5.....	6.0	7.25	8.25	7.2
6.....	7.0	8.0	8.0	7.7
7.....	3.0	5.0	8.0	5.3
8.....	4.5	5.75	7.75	6.0
9.....	2.0	3.5	5.0	3.5
10.....	5.0	8.0	9.25	7.4
11.....	9.0	9.0	9.0	9.0
12.....	6.0	7.75	8.5	7.4
13.....	3.0	4.5	7.0	4.8
14.....	5.5	7.0	8.5	7.0
15.....	2.25	2.0	2.5	2.3
16.....	3.75	6.0	6.5	5.4
17.....	4.5	5.0	7.0	5.5
18.....	5.0	6.0	7.25	6.1
19.....	5.5	5.5	5.5	5.5

The marks are on the basis that you described in your letter of the 19th ult., as follows:

10 to 8, excellent; 8 to 6, good; 6 to 4, fair; 4 to 2, poor; and 2 to 0, failed.

There was a high wind blowing when we made our examination, and we noticed that some of the fastenings were broken or loosened, so there seemed to be some danger of some of the plates being lost if these fastenings are not repaired soon.

We noticed that a number of the plates were missing, usually those of the 900-sq-ft. spreading rate, and not more than one of the three plates in each case. These, we understand from information received at the Pennsylvania Railroad Company Supervisor's office adjacent to the bridge, had been removed intentionally.

Yours very truly,

A. W. CARPENTER,
Engineer of Structures, Ext. Zone.
J. L. HOLST,
Engineer of Structures, Elec. Zone.

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April 9, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Acknowledging receipt of yours of April 8, in the matter of test plates on the Havre de Grace Bridge:

Mr. Carpenter and I will give you a statement some time next week covering our opinion of the relative merits of the paints as applied to the plates and as applied to the structure.

Yours very truly,

J. L. HOLST,
Engineer of Structures.

April 16, 1913.

MR. W. A. AIKEN,
Chairman, Sub-Committee B, Committee D-1,
American Society for Testing Materials.

Dear Sir:

Conforming to yours of April 8, we have the following statement to make, concerning condition of paint films on the Havre de Grace Bridge as compared with the films on experimental plates.

Generally speaking the films on the bridge are superior to same on plates, especially if comparison is made between plates and vertical surfaces on the bridge. The horizontal surfaces on the bridge are in general in worse condition than the vertical surfaces. The films on the vertical surfaces of posts having the same exposure as the plates were, in most cases, distinctly superior to the films on the plates.

Detail observations on each group are as follows:

Group 1.—Bridge films better than plate films. Do not differ much, however, from films on "600" plates.

Group 2.—Bridge films distinctly better than plate films.

Group 3.—Plate films better than bridge films. The films on the bridge were, in general, in slightly worse condition than films on "1200" plates. Poor condition of paint films on bridge especially noticeable on horizontal surfaces and bottom chord.

Group 4.—Bridge films considerably inferior to plate films, especially on horizontal surfaces and bottom chord.

Group 5.—Bridge films better than plate films. Slightly better than the "600" plates, especially superior on face of post having same exposure as plates.

Group 6.—Bridge films slightly inferior to plate films. Mainly due to relatively poor condition of paint films on horizontal surfaces.

Group 7.—Bridge films better than plate films. Bridge films compare favorably with films on "600" plates.

Group 8.—Bridge films inferior to plate films. Bridge films compare with films on "1200" plates. Comparative inferiority of bridge films due largely to poor condition of films on horizontal surfaces.

Group 9.—Bridge films in approximately same condition as films on "900" plates and are considered superior to films on "1200" plates, but inferior to films on "600" plates. Horizontal surfaces on the bridge are in very poor condition. Vertical surfaces not so bad.

Group 10.—Bridge films superior to plate films. The films on the "600" plates are the best of the plate films and are considered slightly inferior to the bridge films. Film on the bridge is thin, is checking and chalking. Notwithstanding this there seems to be at present first-class protection.

Group 11.—Bridge films in approximately same condition as plate films. Material is chalking somewhat but affords first class protection.

Group 12.—Bridge films superior to films on "1200" plates and inferior to films on "600" plates. In approximately same condition as films on "900" plates.

Group 13.—Bridge films better than plate films. The best plate films are on the "600" plates and the bridge films appear superior thereto. This is especially true on vertical surfaces.

Group 14.—Bridge films slightly inferior to films on "600" plates and superior to films on "900" and "1200" plates. The comparison in this case was difficult by reason of the fact that the material did not seem to act the same on the bridge as on the plates. On the plates pitting was distinctly noticeable and there seemed to be no scaling, whereas on the bridge paint had scaled off in a number of instances over areas of 2 or 3 sq. in. and there was relatively a small amount of pitting. If the scaling on the bridge is attributed to faulty execution and disregarded, the films on the bridge are superior to the plate films.

Group 15.—Bridge films better than plate films. They are only slightly superior, however, to films on the "1200" plates.

Group 16.—Bridge films better than plate films. Films on "600" plates are the best of the plate films and films on the bridge are slightly superior to these.

Group 17.—Bridge films are in about the same condition as films on "900" and "1200" plates and are inferior to films on "600" plates.

Group 18.—Bridge films better than plate films especially on the vertical surfaces. Would rate bridge films as slightly better than films on "600" plates.

Group 19.—Bridge films better than plate films. Bridge films are especially superior on vertical surfaces.

In making the above comparisons we used the paint on that portion of the bridge which was accessible from the temporary platform as represent-

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ing the general condition of paint on the bridge. Paint on top chord and floor system was not examined.

Yours very truly,

J. L. HOLST,
Engineer of Structures, Elec. Zone.
 A. W. CARPENTER,
Engineer of Structures, Ext. Zone.

NORFOLK AND WESTERN RAILWAY COMPANY.

ROANOKE, VA., April 17, 1913.

MR. W. A. AIKEN,
 Chairman, Sub-Committee B, Committee D-1,
 American Society for Testing Materials.

Dear Sir:

In accordance with your letter of March 5, I inspected the various paints on test on the Havre de Grace Bridge in company with Mr. J. H. Gibboney on March 26. I returned to Roanoke on March 27, and almost immediately after my return received notice of high water in Ohio which called me to the western end of our line where we were cut off by high water for two weeks, and it was impossible for me to make a report sooner, as I only returned to my office, where I had left all my data, yesterday morning. I very much regret this delay and hope you will excuse the same.

I found it a very difficult matter to make an entirely just rating of the various paints, and in order to aid my judgment in the matter I selected five different points in the various panels and gave each panel a rating for each point, after which I took a general average of the five ratings as being the rating for the panel. I have assumed that any paint which will prevent any marked corrosion *under the conditions of service* at this point for a period of six years should be rated as good, even though the panel at the end of the six years requires re-painting.

Following the rating laid down in your letter to Mr. Churchill of March 1, that is, 8 to 10 being excellent, 6 to 8 being good, 4 to 6 being fair, 2 to 4 being poor and 0 to 2 being failed, I rate these paints as follows:

Paint No.	Rating.	Paint No.	Rating.	Paint No.	Rating.	Paint No.	Rating.
1	5.9	6	7.9	11	7.5	16	7.6
2	5.6	7	6.9	12	7.9	17	6.0
3	5.6	8	5.5	13	6.5	18	7.0
4	5.1	9	6.5	14	7.1	19	6.5
5	7.9	10	7.3	15	4.5	.....	.....

Yours truly,

J. E. CRAWFORD,
Bridge Engineer.

ON INSPECTION OF HAVRE DE GRACE BRIDGE. 349

COMPARISONS OF RATINGS BY SUB-COMMITTEE B AND OUTSIDE INSPECTIONS
OF PAINTS, ON BRIDGE SECTIONS, HAVRE DE GRACE BRIDGE,
MARCH, 1913—ONE YEAR APART.

Description.	Sub-Com- mittee B. 1912.	Penn- sylvania R. R. Co. 1913.	Baltimore & Ohio R. R. Co. 1913.	Philadel- phia & Reading Ry. Co. 1913.	New York Central & Hudson River R. R. Co. 1913.	Norfolk & Western Ry. Co. 1913.
Excellent or Quite Good	6	6	6	6	6	6
	10	10	10	10	10	10
	3	..	3	..	3	..
	11	11	11	11	11	11
	1	1	1	1	..	..
	5	5	5	5	5	5
	12	12	12	12	12	12
	14	..	14	..	14	14
	16	16	16	16	..	16
	17	17	17	17	..	17
	18	18	18	18	..	18
	..	7	..	7	..	7
	..	..	13	..	..	13
	..	..	19	..	..	19
	..	..	..	..	..	9
Fair.....	..	..	..	..	4	..
	4	..	..	..	..	4
	7	..	7	..	7	..
	9	9	..	9	..	..
	13	13	..	13	13	..
	19	19	..	19	19	..
	..	14	..	14	..	..
	..	8	8	8	8	8
	..	3	..	3	..	3
	..	2	..	2	..	2
	..	..	..	..	16	..
	..	..	..	..	17	..
	..	..	..	..	18	..
	..	..	..	..	1	..
	..	..	..	..	..	15
Poor.....	..	4	4	4	..	..
	..	15	..	15	15	..
	..	..	9	..	9	..
	..	..	..	..	2	..
Failed.....	2	..	2	..	..	..
	15	..	15	..	..	..

REPORT OF SUB-COMMITTEE C ON PAINT VEHICLES.

After the completion of a series of preliminary experiments made to determine whether semi-drying oils could be treated so as to be improved in their drying value, a meeting of Sub-Committee C was held in Brooklyn, N. Y., on March 3, 1912. The meeting was attended by Messrs. Thompson, Pickard, Sabin, Toch, Schaeffer, Lane, Ingalls, Voorhees, Nemzek, Boughton, White, Rogers, Lawrie and Gardner.

The committee decided at this meeting that soya and tung oils, on account of their growing use, should be the subject of the year's investigations, with a view to working out reliable tests for determining their value and purity.

TESTS ON SOYA BEAN OILS.

Members of the committee pointed out that soya oils, crushed from various types of beans, might differ in their drying value and general utility as paint oils, and that it would be advisable to develop some quick tests to determine the suitability of raw soya oils as they are found in the market. Mr. Toch stated that his purchases of soya oil were always subject to a heat test conducted in his laboratory, which determined in a short time whether the oil was suitable for use as a paint oil. The committee decided to include such a test in the investigation work on soya oils. A number of samples of soya oils for the tests were obtained from different brokers. These oils were of commercial grade and no data was obtainable as to their purity or source. The samples were labeled and numbered and then submitted to each member of the committee, together with the following instructions as to tests to be made with the oils:

1. *Analytical Constants to be Determined:*

- (a) Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.;
- (b) Saponification number;
- (c) Iodine number (Hanus);
- (d) Acid number.

2. *Heat Test*.—Heat 2 oz. of the oil at 450° F. in a glass receptacle until bleaching is noticed. Then blow a slow current of dry air through the oil until the specific gravity has increased to 0.950. This may require a period of 7 hr. The blowing should be conducted at a temperature between 300° and 370° F. The oil should become light and fairly rapid drying.

3. *Drying Test*.—Place on a table a white sheet of paper 10 cm. square (100 sq. cm. in area). Upon this piece of paper place a weighed and marked piece of ordinary clear window glass about 15 cm. square. On the white area outlined on the paper below the glass, drop about 10 drops of the oil to be tested (approximately 200 mg.). Brush out the oil with a clean camel's-hair brush, so that it will cover the white area. Reweigh the glass to determine the amount of oil thereon. The plate may then be lifted by the edge which is uncoated and placed in a convenient place for drying. The number of hours required for the oil to dry to a firm film should be noted. The change in weight should be determined by reweighing the plate at the end of the third day.

A practical factory test of one of the samples is being conducted by Mr. White.

TESTS ON TUNG OILS.

On account of the adulteration of some shipments of raw Chinese wood oil which have been received in this country, the question arose during the committee meeting as to whether chemical constants or practical heat tests would be more satisfactory in determining the value of this oil. Practical kettle tests in the factory on large amounts of oil will determine whether the oil is suitable for varnish purposes, and such a test is no doubt an important one to make. The general opinion of the committee was to the effect that a laboratory heat test would give equally as much information as a larger test. It was felt that if a series of laboratory heat tests should be made upon a number of samples of tung oil, and the analytical constants of these samples could be determined at the same time, much valuable information would be afforded regarding the composition of such oils, and that such information might be used as the basis for standardization of the analytical constants of tung oils. A series of tung oils was therefore secured from various brokers. No data were obtainable as to their purity or exact source. Labeled and numbered samples were submitted to

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each member of the committee, with instructions to make the following tests:

1. Analytical Constants to be Determined:

- (a) Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.;
- (b) Saponification number;
- (c) Iodine number (Hübl 18 hr.);
- (d) Acid number.

2. *Heat Test*.—Heat 2 oz. of the oil at 420° F. for 20 min. in a glass beaker of 150 cc. capacity. The oil should polymerize. Raise the temperature to 520° F. and hold for 10 min. The oil should be converted into a spongy, semi-solid mass. Test the mass with a knife to see whether it will cut clean without adhering to the knife.

RESULTS OF TESTS.

The results of the tests submitted by members of the committee are given in Tables III–XXII in Appendix I to this report (pages 355–364).

Soya Bean Oils.—In the determination of the analytical constants of soya oil, results which agree very closely were obtained by nearly all of the observers, which would indicate that soya oils have a fairly well defined chemical constitution, even though they may be pressed from various seeds grown in different states. The average constants are given in Table I.

TABLE I.—AVERAGE CONSTANTS OF 9 SAMPLES¹ OF RAW SOYA BEAN OIL AS TAKEN FROM THE RESULTS OF NINE OBSERVERS.

Specific gravity.....	0.9247
Saponification number.....	192.0
Iodine number.....	134.5
Acid number.....	2.14

The heat tests to which the soya oils were subjected gave interesting results, but did not in any case seem to increase the drying value of the oils. It is fairly well established by the tests that most soya oils will bleach under the heat treatment, but the committee is not prepared to state that those oils which do not bleach are unfit for use as paint oils.

¹Soya oil No. 3 omitted for reason stated in note to Table V, Appendix I. Soya oil No. 6 (Blown) omitted from averages.

In the drying tests, as a rule, rapid initial setting was observed with the blown oils, but they remained tacky for a long period of time. Unfortunately, the drying tests on the blown-oil samples gave widely varying results. Toch states that the abnormally high results obtained in his experiments were probably due to the deposition of extraneous matter on the films, the atmosphere where the tests were made being that of a manufacturing city. In another instance the operator flowed the oil upon the plates in thick films, rather than brushing the oil out as outlined in the instructions for the tests. The failure of the various members to obtain concordant results in these drying tests would indicate that the method used is not satisfactory in its present form. Nearly all observers noted a peculiar crawling of the films, which would indicate that raw soya oil is not well adapted to use as a paint oil, unless treated with a drier.

Tung Oils.—The general uniformity of analytical results, except in the case of the McIlhiney test, as shown in the reports of the observers, would indicate that tung oil has definite constants of slight variation. That such constants are of value in determining the purity of tung oil, there can be no doubt.

TABLE II.—AVERAGE CONSTANTS OF 8 SAMPLES OF RAW TUNG OIL AS TAKEN FROM THE RESULTS OF NINE OBSERVERS.

Specific gravity.....	0.9407
Saponification number.....	192.9
Iodine number.....	168.9
Acid number.....	5.69

The purity and value of tung oil should not be judged, however, entirely from the constants of the oil, as the heat test has come to be generally acknowledged as a most valuable asset in determining its purity. The temperature at which the heat test is made is a most important factor for consideration. In the above tests the oil was shown to remain in a liquid condition at 420° F. without apparent polymerization. As a matter of fact, changes of a profound nature occur at such temperature, but they are not apparent until the oil has been cooled and examined chemically and physically. At the high temperature of 520° F., thickening and the formation of a jelly-like mass occurs. The retention of this mass at this temperature for some

time gradually results in the formation of a porous, polymerized product which may be cut easily with a knife, while hot, like ginger-bread. Several of the observers commented upon the semi-solid state of the mass around the sides of the vessels in which the heat tests were conducted. This same condition is observed even with constant stirring of the oil during the initial stages of polymerization, but is obviated if a temperature of 540° F. rather than 520° F. is maintained. At the higher temperature much better results are obtained. The Committee on Wood Oil Tests of the New York Produce Exchange has recently adopted a heat test for determining the purity of wood oil, and their specifications state that the oil shall be rapidly heated to 540° F. and held at that temperature for 7½ minutes. It is stated that complete polymerization is shown by all pure wood oils in such a test.

The McIlhiney test,¹ in which the iodine non-precipitable matter was estimated, did not in every case give concordant results. The analytical procedure is subject to improvement.

The Hanus and Wijs methods for determining the iodine number of oil have not given satisfactory results with wood oil in the past. The Hübl method is apparently better adapted for this purpose. Whether the 18-hour test is necessary, is a question that should be determined by additional tests.

A further report of the sub-committee on "Specifications for Turpentine" is given in Appendix II to this report (pages 365-368).

Respectfully submitted on behalf of the sub-committee,

H. A. GARDNER,
Chairman.

¹ *Journal of Industrial and Engineering Chemistry*, 1912.

APPENDIX I.
DETAIL RESULTS OF TESTS OF SOYA BEAN OILS AND
TUNG OILS.

TABLE III.—SOYA BEAN OIL No. 1.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value. ¹
Gardner.....	0.9210	190.0	132.6	1.20	Same color; viscous.	0.926	1.20+	Oil crawled on plate in drying test. Blown 12 hr.	10mm.
Boughton.....	0.9248	197.4	134.1	2.50	Bleached.....	0.943	3.10+		
Lindsay.....	0.9248	190.2	133.7	1.21	Bleached well...	0.959	6.86+		
Lawrie.....	0.9220	191.4	132.0	2.40	Bleached.....	0.937	1.10+		
Toch.....	0.9250	196.5	129.7	2.20	Good.....	.....	10.00+	
Jackman & Stoppel	0.9248	192.4	132.2	2.24	Darkened.....	0.959	0.28+		
Kohr & Mougey	0.9248	194.9	135.2	1.30	Same color.....	0.951	0.39+		
Pickard.....	0.9242	189.4	130.3	2.50	.....	.....	4.40+
White & Boyle	0.9248	191.1	131.4	1.09	.....	.....	0.47+
Average.....	0.9240	192.6	132.4	1.85	.....	0.944	3.09+	

¹ Color.—The color was compared with standard Lovibond glasses in a Schreiner colorimeter. A depth of 10 mm. of soya bean oil No. 1 was matched against a combination of glasses and used as a standard against which different depths of the other oils were matched.

TABLE IV.—SOYA BEAN OIL No. 2.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9210	190.0	135.2	2.50	Same color; viscous.	0.924	Lost	Oil crawled on plate in drying test. Blown 12 hr.	9 mm
Boughton.....	0.9251	196.3	135.3	2.10	Bleached slightly.	0.941	0.10+		
Lindsay.....	0.9246	188.3	134.2	2.29	Bleached.....	0.959	6.40+		
Lawrie.....	0.9210	194.4	132.4	1.90	Bleached.....	0.946	0.90+		
Toch.....	0.9250	191.0	130.5	2.10	Good.....	.....	12.00+	
Jackman & Stoppel	0.9249	191.7	133.9	1.96	Darkened.....	0.952	0.12+		
Kohr & Mougey	0.9257	189.0	137.3	2.30	Same color.....	0.950	0.19+		
Pickard.....	0.9246	185.6	133.8	2.20	3.20+		
White & Boyle	0.9248	191.0	131.1	2.11	1.31+		
Average.....	0.9241	190.8	133.7	2.16	0.945	3.03+		

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TABLE V.—SOYA BEAN OIL NO. 3.¹

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9320	191.0	126.8	3.50	Darker; viscous.	0.931	0.50+	Blown 12 hr.	6 mm.
Boughton.....	0.9357	198.2	128.3	3.60	Same color.....	0.952	4.35+		
Lindsay.....	0.9350	194.1	126.2	3.60	Darkened.....	0.959	9.87+		
Lawrie.....	0.9310	190.6	123.2	2.80	Darkened.....	0.941	1.30+		
Tooh.....	0.9350	192.0	119.4	3.60	Same color.....	.....	10.30+	
Jackman & Stoppel } Kohr & Mougey	0.9355	194.9	122.7	3.36	Darkened.....	0.950	0.43+		
Pickard.....	0.9352	187.6	126.0	3.70	.....	.....	6.10+
White & Boyle.	0.9354	195.0	120.6	3.62	.....	.....	4.76+
Average.....	0.9345	193.0	124.7	3.49	.....	0.947	4.25+	

¹ On account of the low constants shown by this oil, it was not considered pure and the constants were not included in the averages.

TABLE VI.—SOYA BEAN OIL NO. 5.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9220	194.0	134.5	3.10	Lighter.....	0.925	0.10+	Oil crawled on plate in drying test. Blown 21 hr.	10 mm.
Roughton.....	0.9256	197.7	134.9	3.30	Bleached.....	0.945	6.70+		
Lindsay.....	0.9255	191.0	134.9	3.31	Bleached slightly.	0.962	6.07+		
Lawrie.....	0.9200	198.5	131.3	2.80	Bleached.....	0.971	0.80+		
Tooh.....	0.9340	194.8	130.7	3.30	Bleached slightly.	.....	10.70+	
Jackman & Stoppel } Kohr & Mougey	0.9257	194.3	132.6	2.80	Darkened.....	0.954	0.13+		
Pickard.....	0.9246	189.5	133.0	3.30	.....	.....	3.80+
White & Boyle.	0.9254	193.5	131.2	3.31	.....	.....	4.98+
Average.....	0.9253	193.9	133.3	3.19	.....	0.951	3.77+	

TABLE VII.—SOYA BEAN OIL No. 6 (BLOWN).

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanna.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9760	211.0	90.9	5.60	0.976	Lost	Oil blown when submitted to committee.	27mm.
Boughton.....	0.9788	213.1	98.0	7.70	.....	.....	0.36+	"
Lindsay.....	0.9750	.....	.....	.....	.....	.....	.....	"
Lawrie.....	0.9730	193.3	88.3	6.00	.....	.....	1.30+	"
Toch.....	0.9780	211.2	76.8	7.12	.....	.....	10.00+	"
Jackman & Stoppel	0.9785	220.3	86.5	4.76	.....	.....	0.79+	"
Kohr & Mougey	0.9785	203.9	94.8	7.30	.....	.....	.....	"
Pickard.....	0.9760	207.6	95.9	6.90	.....	.....	3.60+	"
White & Boyle	0.9756	197.0	90.2	6.64	.....	.....	2.62+	"
Average.....	0.9766	207.2	90.2	6.50	.....	.....	3.11+	"

TABLE VIII.—SOYA BEAN OIL No. 7.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanna.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9220	191.0	134.1	1.80	Lighter; viscous.	0.925	0.90+	Oil crawled on plate in drying test. Blown 17 hr.	10mm
Boughton.....	0.9253	196.4	133.8	1.70	Bleached slightly.	0.948	0.65+		
Lindsay.....	0.9252	189.6	134.9	1.58	Same color.....	0.951	6.35+		
Lawrie.....	0.9220	192.0	133.1	1.40	Bleached.....	0.923	1.60+		
Toch.....	0.9245	194.5	129.6	1.80	Good.....	.....	11.10+	
Jackman & Stoppel	0.9254	192.1	132.2	1.54	Bleached.....	0.950	1.28+		
Kohr & Mougey	0.9250	193.9	135.2	1.90	Much darker....	0.950	.....	
Pickard.....	0.9248	189.1	133.5	1.60	6.80+		
White & Boyle	0.9248	193.0	130.4	1.70	2.96+		
Average.....	0.9243	192.1	132.9	1.67	0.941	3.96+		

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TABLE IX.—SOYA BEAN OIL No. 8.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9240	195.0	136.3	1.00	Lighter; viscous.	0.924	0.90+	Oil crawled on plate in drying test. Blown 11 hr.	10mm.
Boughton.....	0.9244	192.3	136.3	0.50	Bleached.....	0.951	0.35+		
Lindsay.....	0.9244	191.3	134.6	0.92	Bleached.....	0.955	8.02+		
Lawrie.....	0.9200	191.6	133.3	0.60	Bleached.....	0.923	Lost		
Toch.....	0.9250	191.3	130.6	0.81	Good.....	.....	15.60+	
Jackman & Stoppel }	0.9248	192.4	132.8	0.70	Bleached.....	0.950	0.53+		
Kohr & Mougey	0.9242	188.9	136.2	1.00	Same color.....	0.950	0.25+		
Pickard.....	0.9245	187.1	135.1	0.76	.....	.....	0.87+
White & Boyle.	0.9239	196.0	131.6	0.89	.....	.....	0.32+
Average.....	0.9239	191.8	134.1	0.80	.....	0.942	3.36+	

TABLE X.—SOYA BEAN OIL No. 9.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9220	198.0	138.1	1.50	Darker; viscous.	0.924	0.30+	Blown 12 hr.	4 mm.
Boughton.....	0.9260	193.6	139.0	1.70	Same color.....	0.946	0.20+		
Lindsay.....	0.9263	191.2	137.7	1.70	Bleached well.....	0.956	4.23+		
Lawrie.....	0.9210	192.8	134.9	1.40	Bleached.....	0.970	0.20+		
Toch.....	0.9262	195.8	132.9	1.50	Good.....	.....	11.90+	
Jackman & Stoppel }	0.9258	192.8	136.3	1.54	Bleached.....	0.955	2.45+		
Kohr & Mougey	0.9260	190.3	139.3	1.70	Darkened slightly.	0.960	0.08-		
Pickard.....	0.9254	185.9	139.2	1.60	.....	.....	3.40+
White & Boyle.	0.9255	195.0	134.3	1.62	.....	.....	3.54+
Average.....	0.9249	192.8	136.9	1.58	.....	0.950	3.02+	

TABLE XI.—SOYA BEAN OIL No. 10.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9230	191.0	138.5	1.40	Lighter; viscous.	0.925	2.00+	Blown 10 hr.	4 mm.
Boughton.....	0.9260	914.8	137.8	1.50	Same color.....	0.953	0.95+		
Lindsay.....	0.9260	191.4	136.4	1.57	Bleached well....	0.962	2.26+		
Lawrie.....	0.9220	192.8	134.8	1.10	Bleached.....	0.971	1.10+		
Toeh.....	0.9260	193.8	134.5	1.23	Fair.....		15.00+		
Jackman & Stoppel	0.9259	192.8	135.7	1.26	Bleached.....	0.949	1.09+		
Kohr & Mougey	0.9269	187.6	139.5	1.50		0.950	0.26—		
Pickard.....	0.9255	188.8	137.3	1.30			3.10+		
White & Boyle.	0.9255	190.0	133.7	1.47			7.24+		
Average.....	0.9252	191.4	136.6	1.37		0.952	3.61+		

TABLE XII.—SOYA BEAN OIL No. 11.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9230	192.0	137.8	3.70	Darker; viscous	0.923	0.80+	Dark brown precipitate formed.	6 mm.
Boughton.....	0.9263	194.3	139.0	5.60	Same color.....	0.943	0.35+		
Lindsay.....	0.9263	191.6	137.4	4.45	Same color.....	0.964	5.17+		
Lawrie.....	0.9220	190.5	134.7	3.40	Bleached.....	0.943	2.70+		
Toeh.....	0.9270	193.4	134.4	3.50	Bleached slightly.		10.00+		
Jackman & Stoppel	0.9265	192.4	135.7	4.48	Darkened.....	0.955	1.66+		
Kohr & Mougey	0.9267	187.9	138.8	5.80	Darkened slightly.	0.950	1.02+		
Pickard.....	0.9260	187.8	138.6	5.90			6.30+		
White & Boyle.	0.9251	191.0	133.7	4.83			5.85+		
Average.....	0.9254	191.2	136.7	4.63		0.946	3.76+		

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TABLE XIII.—SOYA BEAN OIL No. 12.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hama.	Acid Number.	Heat Test Remarks.	Sp. Gr. Heated Oil.	Change in Weight of Heated Oil in 3 days, per cent.	Remarks.	Color Value.
Gardner.....	0.9220	190.0	133.1	1.80	Darker; viscous.	0.924	3.50+	Dark brown precipitate formed.	8 mm.
Boughton.....	0.9265	194.3	138.7	2.10	Same color.....	0.954	0.15+		
Lindsay.....	0.9263	190.4	135.3	2.17	Darkened slightly.	0.959	6.23+		
Lawrie.....	0.9220	193.7	132.2	1.70	Darkened.....	Lost	3.10+		
Toch.....	0.9260	192.2	132.6	1.94	.....	.....	10.40+
Jackman & Stoppel }	0.9265	192.8	134.5	1.82	Darkened.....	0.953	6.48+	Blown 15 hr.	
Kohr & Mougey	0.9269	189.4	137.4	2.40	Darkened.....	0.950	0.41+		
Pickard.....	0.9259	187.5	133.5	2.20	.....	.....	7.50+
White & Boyle.	0.9257	191.0	131.0	1.94	.....	.....	7.05+
Average.....	0.9253	191.3	134.3	2.01	0.948	4.98+		

TABLE XIV.—TUNG OIL No. 20.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Mellinney Test, ¹ per cent.	Remarks.	Color Value. ²
Gardner.....	0.9370	192.0	169.4	4.60	Polymerized around edge.	Polymerized completely in 6 min.; medium color.	37.90	Good quality.	10 mm
Boughton.....	0.9415	197.0	162.6	6.20	Not polymerized.	Jelly-like; cut clean.	.....	
Lindsay.....	0.9408	192.1	170.9	6.16	Sticky at edge.	Polymerized; cut clean in center.	12.18		
Lawrie.....	0.9370	193.7	171.3	4.40	Polymerized slightly.	Polymerized completely.	13.90		
Toch.....	0.9400	192.3	167.8	6.30	.....	.....	.....
Jackman & Stoppel }	0.9409	193.4	168.5	4.76	Unchanged.....	Polymerized.....	18.54		
Kohr & Mougey	0.9420	191.0	172.5	6.40	No action.....	Solidified in 7 min.	.....	
Pickard.....	0.9399	190.9	159.6	6.10	Polymerized around edge.	Jelly-like; cut clean.	21.80		
White & Boyle.	0.9392	193.8	171.5	6.18	No change.....	Polymerized.....	.....	
Average.....	0.9398	192.9	168.2	5.68	20.86		

¹ *Journal of Industrial and Engineering Chemistry*, 1912.² Color.—The color was compared with standard Lovibond glasses in a Schreiner colorimeter. A depth of 10 mm. of tung oil No. 20 was matched against a combination of glasses and used as a standard against which different depths of the other oils were matched.

TABLE XV.—TUNG OIL No. 21.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Melbliness Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9390	193.0	169.6	12.50	Polymerized around edge.	Polymerized completely in 6 min.; medium color.	37.90	Good quality.	11 mm.
Boughton.....	0.9430	199.3	164.8	10.20	Not polymerized.	Jelly-like; cut clean.	.....	
Lindsay.....	0.9425	193.6	172.1	10.96	Sticky at edge.	Polymerized; cut clean in center.	14.25		
Lawrie.....	0.9390	190.8	172.6	8.10	Polymerized slightly.	Polymerized completely.	13.00		
Toch.....	0.9430	196.8	165.4	10.50	.....	.....	.....
Jackman & Stoppel } Kohr & Mougey	0.9424	193.3	169.0	8.26	Unchanged.....	Polymerized.....	16.54		
Pickard.....	0.9433	191.2	170.2	10.90	No action.....	Solidified in 5 min.	.....	
Pickard.....	0.9414	191.2	161.6	10.70	Polymerized around edge.	Jelly-like; cut clean.	22.80		
White & Boyle.	0.9398	199.6	171.9	10.38	No change.....	Polymerized.....	.....	
Average.....	0.9415	194.3	168.6	10.28	.....	.....	20.80	

TABLE XVI.—TUNG OIL No. 22.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Melbliness Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9370	186.0	163.5	1.80	Polymerized slightly around edge.	Polymerized completely in 10 min.; very light color.	37.00	Good quality.	22 mm.
Boughton.....	0.9415	196.6	163.1	2.00	Not polymerized.	Jelly-like; cut clean.	.....	
Lindsay.....	0.9408	191.6	173.9	2.07	Sticky at edge.....	Polymerized; cut clean in center.	11.68		
Lawrie.....	0.9380	191.3	171.4	1.30	Polymerized slightly.	Polymerized completely.	10.40		
Toch.....	0.9430	192.6	161.8	1.29	.....	.....	.....
Jackman & Stoppel } Kohr & Mougey	0.9409	192.8	168.6	1.40	Unchanged.....	Polymerized.....	11.87		
Pickard.....	0.9415	187.7	172.0	2.20	No action.....	Solidified in 8 min.	.....	
Pickard.....	0.9400	187.9	160.6	1.70	Polymerized around edge.	Jelly-like; cut clean.	13.70		
White & Boyle	0.9388	196.9	172.6	1.84	No change.....	Polymerized.....		
Average.....	0.9402	191.5	167.5	1.73	16.93		

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TABLE XVII.—TUNG OIL No. 23.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Mellinney Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9380	194.0	166.3	7.20	Polymerized slightly around edge.	Polymerized completely in 9 min.; dark color.	38.40	Not as good as Nos. 20 and 21.	12mm.
Boughton.....	0.9406	195.7	163.0	9.10	Not polymerized.	Jelly-like; cut clean.	18.60	Very turbid oil.	
Lindsay.....	0.9408	193.0	172.3	8.91	.....	Jelly-like and sticky.	20.25	.....
Lawrie.....	0.9380	193.3	170.0	6.00	Polymerized slightly.	Polymerized completely.	18.90	.....
Toch.....	0.9410	196.2	164.4	9.30	.....	.....	.....	.....
Jackman & Stoppel } Kohr & Mougey	0.9408	194.1	168.0	6.72	Unchanged.....	Polymerized.....	20.94	.....
Pickard.....	0.9420	188.1	172.5	7.40	No action.....	Solidified in 5 min.	.....	.....
White & Boyle.....	0.9403	190.9	163.2	8.30	Polymerized around edge.	Jelly-like; cut clean.	33.40	.....
Average.....	0.9400	.....	170.6	8.36	No change.....	Polymerized.....	.....	.....
	0.9402	193.2	167.8	7.92	25.08	

TABLE XVIII.—TUNG OIL No. 25.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Mellinney Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9370	189.0	169.2	8.40	Polymerized slightly around edge.	Polymerized completely in 10 min.; very dark color.	29.00	Good.	12mm.
Boughton.....	0.9407	197.2	164.4	10.00	Not polymerized.	Jelly-like; cut clean.	14.70	.....
Lindsay.....	0.9402	191.5	173.5	10.05	Sticky jelly.	Did not cut clean.	12.53	.....
Lawrie.....	0.9380	188.3	172.5	6.50	Polymerized slightly.	Polymerized completely; slower than others.	10.90	.....
Toch.....	0.9405	195.2	164.5	9.30	.....	.....	.....	.....
Jackman & Stoppel } Kohr & Mougey	0.9402	192.4	168.4	7.70	Unchanged.....	Polymerized.....	16.51	.....
Pickard.....	0.9417	193.3	172.6	10.40	No action.....	Solidified in 8 min.	.....	.....
White & Boyle.....	0.9401	189.9	161.8	9.50	Polymerized around edge.	Jelly-like; cut clean.	19.50	.....
Average.....	0.9391	.....	173.8	9.72	No change.....	Polymerized (sticky).	.....	.....
	0.9397	192.1	168.0	9.06	17.19	

TABLE XIX.—TUNG OIL No. 26.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	McIlhenny Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9390	193.0	167.7	1.90	Polymerised slightly around edge.	Polymerised completely in 4 min.; very dark color.	21.10	Very good quality.	9 mm.
Boughton.....	0.9423	196.0	167.7	2.90	Not polymerised..	Jelly-like; cut clean.	.....	Strong odor.
Lindsay.....	0.9421	190.9	174.3	1.86	Sticky at edge....	Polymerized; cut clean in center.	11.84		
Lawrie.....	0.9390	192.0	173.0	1.50	Polymerised slightly.	Polymerised completely.	11.10		
Toch.....	0.9430	194.9	167.2	1.73	.....	.....	.....
Jackman & Stoppel	0.9423	192.5	169.4	1.70	Unchanged.....	Polymerised.....	12.50		
Kohr & Mougey	0.9433	192.6	170.3	1.70	No action.....	Solidified in 5 min.	.....	
Pickard.....	0.9419	188.3	159.9	1.90	Polymerised around edge.	Jelly-like; cut clean.	15.60		
White & Boyle	0.9401	.....	175.5	1.60	No change.....	Polymerised.....	.....	
Average.....	0.9414	192.5	169.4	1.87	.....	.....	14.43	

TABLE XX.—TUNG OIL No. 27.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	McIlhenny Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9380	193.0	171.2	6.20	Polymerised slightly around edge.	Polymerised completely in 10 min.; medium color.	31.40	Good quality.	18 mm
Boughton.....	0.9413	198.1	165.4	8.10	Not polymerised..	Jelly-like; cut clean.	.....	
Lindsay.....	0.9402	192.2	173.8	8.06	Sticky at edge...	Polymerized; cut clean in center.	10.51		
Lawrie.....	0.9380	191.8	172.1	5.30	Polymerised slightly.	Polymerised completely.	10.70		
Toch.....	0.9415	196.2	166.3	7.70	.....	.....	.....
Jackman & Stoppel	0.9413	194.1	171.6	6.02	Unchanged.....	Polymerised.....	15.26		
Kohr & Mougey	0.9425	193.0	173.6	8.10	No action.....	Solidified in 5 min.	.....	
Pickard.....	0.9411	188.9	171.7	7.90	Polymerised around edge.	Jelly-like; cut clean.	7.20		
White & Boyle	0.9394	174.1	7.67	No change.....	Polymerised.....		
Average.....	0.9404	193.4	171.1	7.23	15.01		

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TABLE XXI.—TUNG OIL No. 28.

Observer.	Sp. Gr. at 15° C.	Saponification Number.	Iodine Number, Hübl, 18 hr.	Acid Number.	Heat Test at 420° F., 20 min.	Heat Test at 520° F., Remarks.	Mellinney Test, per cent.	Remarks.	Color Value.
Gardner.....	0.9400	195.0	171.2	1.00	Polymerised slightly around edge.	Polymerised completely in 10 min.; very light color.	14.10	Fair quality.	10 mm
Boughton.....	0.9436	196.1	165.1	1.30	Notpolymerised.	Jelly-like; cut clean.	.....	
Lindsay.....	0.9428	191.9	174.6	1.40	Sticky at edge....	Polymerised; cut clean in center.	11.42		
Lawrie.....	0.9400	191.6	173.0	6.70	Polymerised slightly.	Polymerised completely; slower than others.	9.60		
Tooh.....	0.9400	193.5	170.4	0.98	.....	.....	.....
Jackman & Stoppel } Kohr & Mougey	0.9434	192.8	170.5	0.84	Unchanged.....	Polymerised.....	11.93		
Pickard.....	0.9441	194.3	172.7	1.00	No action.....	Solidified in 6 min.	.....	
Pickard.....	0.9432	189.5	163.3	1.20	Polymerised around edge.	Jelly-like; cut clean.	13.50		
White & Boyle.	0.9425	.....	174.6	1.11	No change.....	Polymerised.....	.....	
Average.....	0.9422	193.1	170.6	1.73	.....	.....	12.11	

ADDENDA

TABLE XXII.—DATA ON DENSITY OF OILS¹ USED IN TESTS, BY
H. C. BEARCE, BUREAU OF STANDARDS.*Density of Soya Bean Oils.*

Oil No.	D ^{15°} _{4° C.}	D ^{15°} _{4° C.}	D ^{15°} _{15° C.}	D ^{25°} _{4° C.}	D ^{25°} _{25° C.}	Between ² 15°-30° C.	B. S. Nos.
1	0.92462	0.92427	0.92515	0.91761	0.92030	0.00070	3975
2	0.92460	0.92426	0.92514	0.91771	0.92040	0.00069	3976
3	0.93518	0.93484	0.93573	0.92829	0.93101	0.00069	3977
5	0.92532	0.92498	0.92586	0.91852	0.92121	0.00068	3978
6	0.97740	0.97706	0.97799	0.97058	0.97343	0.00068	3979
7	0.92499	0.92465	0.92553	0.91814	0.92083	0.00068	3980
8	0.92428	0.92394	0.92482	0.91750	0.92019	0.00068	3981
9	0.92544	0.92510	0.92598	0.91863	0.92132	0.00068	3982
10	0.92550	0.92516	0.92604	0.91866	0.92135	0.00068	3983
11	0.92648	0.92614	0.92702	0.91970	0.92240	0.00068	3984
12	0.92613	0.92579	0.92667	0.91930	0.92199	0.00068	3985

Density of Tung Oils.

Oil No.	D ^{15°} _{4° C.}	D ^{15°} _{4° C.}	D ^{15°} _{15° C.}	D ^{25°} _{4° C.}	D ^{25°} _{25° C.}	Between ² 15°-30° C.	B. S. Nos.
20	0.93996	0.93963	0.94052	0.93331	0.93605	0.00067	3986
21	0.94204	0.94169	0.94259	0.93512	0.93786	0.00069	3987
22	0.94049	0.94015	0.94104	0.93360	0.93634	0.00069	3988
23	0.94044	0.94010	0.94099	0.93356	0.93630	0.00069	3989
25	0.93982	0.93948	0.94037	0.93262	0.93535	0.00069	3990
26	0.94201	0.94167	0.94257	0.93481	0.93755	0.00069	3991
27	0.94084	0.94050	0.94139	0.93362	0.93636	0.00069	3992
28	0.94296	0.94262	0.94352	0.93579	0.93853	0.00068	3993

¹ $D_{t'}^{t'}$ = specific gravity at t' referred to water at t' as unity. When $t' = 4^{\circ} \text{C.}$, the specific gravity is numerically the same as density in grams per cubic centimeter.

² Change of density per degree change of temperature.

APPENDIX II.

SPECIFICATIONS FOR TURPENTINE.

A meeting of Sub-Committee C was held on June 15, 1912, at The Institute of Industrial Research, Washington, D. C., and was attended by Messrs. Veitch, Boughton and Gardner. Communications from Messrs. Teeple, Gibboney and Herty were read at the meeting. Tentative specifications for turpentine were drawn up and submitted simply for consideration as follows:

TENTATIVE SPECIFICATIONS FOR TURPENTINE.

TURPENTINE. No. 1.

These specifications apply both to the turpentine that is distilled from pine oleoresin and generally known as gum turpentine, and the turpentine that is distilled from wood and generally known as wood turpentine. The committee does not attempt to differentiate between the two, provided they fully meet all requirements. The purchaser when submitting these specifications may at his option specify either product.

Color.—The turpentine shall be perfectly clear, free from suspended material, and water white. The color shall be determined by matching a sample 200 mm. in depth with a No. 1 Lovibond glass in a Schreiner colorimeter. The turpentine shall not show a greater color than the standard glass.

Specific Gravity.—The specific gravity shall not be less than 0.862 nor more than 0.870 at 20° C.

Refractive Index.—The refractive index shall be from 1.468 to 1.476 at 20° C.

Boiling Point.—The boiling point shall be between 152° and 158° C.

Distillation Test.—When 200 cc. of the turpentine are distilled, 95 per cent shall pass over below 170° C.

For this test use a 300-cc. flask, 8 cm. in diameter, with a side tube 8 cm. from the main bulb, and the neck extending

8 cm. above the side tube. The neck is 2 cm. in diameter and the side tube is 5 mm. This flask should be fitted with a thermometer (reading from 145° to 200° C.) immersed in the vapor. The mercury bulb should be opposite the side tube of the flask and the reading 175° C. should be below the cork. The distillation should be so conducted that there shall pass over about two drops of the distillate per second.

Polymerization.—When 5 cc. of the sample are treated with sulphuric acid of specific gravity 1.84, according to the method herewith outlined there shall remain undissolved at the end of thirty minutes not over 0.09 cc. The residue unpolymerized should show a refraction value of not less than 1.50 to 1.52. It should be viscous in nature. If the residue is water-white, limpid, and does not show the proper refraction value, it should be carefully polymerized with 38-N sulphuric acid according to Veitch.¹

For this test, add slowly 5 cc. of the turpentine to 25 cc. of 1.84 sulphuric acid contained in an ordinary graduated narrow-neck Babcock flask. Shake the flask with a rotary motion to insure gradual mixing. Cool, if necessary, in ice water, not permitting the temperature to rise above 60° to 65° C. Agitate thoroughly, and maintain at about 65° C. with frequent agitations for one hour. Cool, fill the flask with sulphuric acid, bringing the unpolymerized oil into the graduated neck. Allow to stand one hour. Read off the unpolymerized content, note its consistency and color, and determine its refractive index.

Color Test.—Shake 10 cc. of the turpentine with 10 cc. of concentrated hydrochloric acid in a test tube. The development, after three minutes standing, of a decided red color is indicative of the presence of other (usually heavy) resinous oils.

Evaporation Test.—Place 10 cc. of the sample in a glass crystallizing dish, 2½ in. in diameter and 1½ in. high, and evaporate on an open steam bath with a full head of steam until there is no more loss in weight. The residue shall not weigh more than 0.150 g.

¹ *Bulletin No. 156*, p. 30, or *Circular No. 86*, Bureau of Chemistry, Department of Agriculture.

On November 16, 1912, the above specifications were considered at the meeting of the committee held at the Bureau of Chemistry, Washington, D. C. It was decided not to recommend any specifications for adoption until tests had been made upon samples of turpentine obtained by members of the committee from authoritative and reliable sources. Members of the committee will secure such samples in the field at the time of manufacture, and quantities of each sample will be submitted to the various members of the committee to use in studying the methods embraced in the foregoing tentative specifications. The procedure for this work which was then submitted to the committee is as follows:

SUGGESTED PROCEDURE FOR THE ANALYSIS OF TURPENTINE.

Color.—Note and report whether the material is free from dirt and suspended matter and is water white. Determine the color by comparing a sample 200 mm. in depth over a No. 1 Lovibond glass, with a No. 2 Lovibond glass in a colorimeter. Note and report whether the turpentine plus the No. 1 glass is lighter or darker in color than the No. 2 glass.

Specific Gravity.—Determine the specific gravity by any suitable accurate method and report figure as specific gravity at 15°.5/15°.5 C. State method used.

Refractive Index.—Determine with a direct reading refractometer at 15°.5 C.

Distillation Test.

Test 1.—For this test use a 300-cc. flask, 8 cm. in diameter, with a side tube 8 cm. from the main bulb, and the neck extending 8 cm. above the side tube. The neck is 2 cm. in diameter and the side tube is 5 mm. This flask should be fitted with a thermometer (reading from 145° to 200° C.) immersed in the vapor. The mercury bulb should be opposite the side tube of the flask and the reading 175° C. should be below the cork. The distillation should be so conducted that there shall pass over about two drops of the distillate per second.

Test 2.—For this test use the ordinary Engler flask as shown on page 503 of *Engineering Chemistry* by Stillman. Have the thermometer totally immersed in the vapor as directed in the specifications in Test 1. In Test 2 use 100 cc. of turpentine to determine whether the same results are obtained as with 200 cc. of turpentine.

Test 3.—Use the ordinary Engler flask as described in Test 2, and an ordinary long stem thermometer. Determine approximate length of the mercury column outside the flask at the distillation temperatures.

In all three methods of distillation note and report the initial boiling point and the percentage of distillate obtained below 170° C., and the barometric pressure at the time of making the distillation.

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Polymerisation.

Test 1.—Add slowly 5 cc. of the turpentine to 25 cc. of 1.84 sulphuric acid contained in an ordinary graduated narrow-neck Babcock flask. Shake the flask with a rotary motion to insure gradual mixing. Cool, if necessary, in ice water, not permitting the temperature to rise above 60° to 65° C. Agitate thoroughly and maintain at about 65° C. with frequent agitations for one hour. Cool, fill the flask with sulphuric acid, bringing the unpolymerized oil into the graduated neck. Allow to stand one hour. Read off the unpolymerized content; note and report its consistency and color, and determine its refractive index at 15°.5 C.

Test 2 (Veitch's Method¹).—Repeat Test 1, but use 38-N sulphuric acid and let flasks stand 24 hours before reading the amount of unpolymerized residue, or else centrifuge five minutes.

Hydrochloric Acid Test.—Shake 10 cc. of the turpentine with 10 cc. of concentrated hydrochloric acid, specific gravity 1.19. Note whether after three minutes-standing a decided red color develops. Test for the presence of other usually heavy or resinous oils.

Evaporation Test.—Place 10 cc. of the sample in a glass crystallizing dish, 2½ in. in diameter and 1½ in. high, and evaporate on an open steam bath with a full head of steam for 2 hours. Cool, weigh, and report weight of residue in grams.

Flash Point.

Test 1.—Support a 100-cc. nickel crucible, such as is used in determining the flash point of linseed oil, in a vessel of water at 15° to 20° C.; the water should cover about two-thirds of the crucible. Fill the crucible to within about 2 cm. of the top with turpentine, insert a thermometer, and heat the water bath slowly so that the temperature of the turpentine rises 1° C. per minute. Begin at 37° C. and test for the flash at each rise of 0°.5 C. Report temperature at which the turpentine flashes.

Test 2.—Determine the flash point using the Tagliabue open cup. Begin testing at 30° C. and test at each degree Centigrade above that till the sample flashes. The temperature of the turpentine should not rise more rapidly than 1° C. per minute.

Test 3.—Use a closed tester such as the Pensky-Martin tester, the Abel cup, etc., following the directions for the instrument.

It is thought that the authoritative samples for the tests will not be received before the end of June. The report on the tests will therefore be made next year.

Respectfully submitted on behalf of the sub-committee,

H. A. GARDNER,

Chairman.

¹ *Bulletin No. 135*, p. 30, or *Circular No. 85*, Bureau of Chemistry, Department of Agriculture.

REPORT OF SUB-COMMITTEE D ON
THE ATLANTIC CITY STEEL PAINT TESTS.

The Atlantic City Steel Paint Tests were originally designed by members of the American Society for Testing Materials, with the object in view of determining by practical exposure tests whether certain single pigments would, when enveloped in an oil film, offer the same relation to the protection or to the corrosion of iron or steel that was exhibited by these pigments in laboratory tests when placed in contact with steel plates in the presence of water. A series of pigments which had been under experimentation in the water tests were therefore selected for the exposure tests and after being ground in linseed oil, the quantity of which was determined in every instance by the specific gravity of the individual pigments, were applied to steel and iron plates and subjected to exposure. That the results obtained from these tests would have been modified to some degree had the tests been made more diversified in respect to the quantity of liquids used in the grinding of the pigments, there can be no doubt. It is, however, fair to state that the tests have offered considerable information as to the relative value of various pigments as components of structural paints and that they have presented much valuable data upon which to base future tests of a more extended nature.

Although a complete history of the tests, including the data regarding the preparation and application of the paints, is to be found in the Proceedings of the Society,¹ the committee is presenting herewith, for the benefit of those who are not familiar with previous reports, an outline of the tests as summarized in the Proceedings of 1910:

"Three years ago the suggestion was made in a paper presented before the Tenth Annual Meeting of this Society,² that the various types of substances used as pigments in protective coatings might exert a stimulative or an inhibitive action on the rate and tendency to corrosion of the underlying metal. It was further suggested on theoretical grounds that slightly soluble chromates should exert a protective action when employed

¹ Vol. IX, pp. 203-204 (1909); Vol. X, pp. 73-86 (1910); Vol. XI, pp. 192-194 (1911).

² "The Corrosion of Iron," A. S. Cushman, *Proceedings*, Vol. VII, p. 211 (1907).

as pigments, by maintaining the surface of the iron in a passive condition in case water and oxygen penetrated the paint film. In view also of the well-known fact that alkalis inhibit while acids stimulate the corrosion of iron, it was suggested that the action of more or less pure pigments on iron in the presence of water be thoroughly investigated. Two years ago this committee invited the cooperation of Committee D-1 (then known as Committee E) in the investigation, and a special sub-committee representing the two main committees was appointed.

"Briefly, the method consisted in immersing samples of steel in water suspensions of the various pigments and blowing air through the containers for definite periods of time, the corrosion being measured by the loss in weight sustained by the test pieces. About fifty pigments which are in more or less common use for painting steel were purchased in the open market and distributed among a number of the members of the committee, who agreed to carry out the work. Each investigator worked independently of the others, except that the same general method was followed; the time of exposure to the corroding action, however, varied in the different experiments. When the results were compared and analyzed by the sub-committee, it was felt that the general agreement of the results obtained by the several investigators was striking and merited further and more systematic work. As a result of these tests the sub-committee tentatively divided the pigments into inhibitors, stimulators, and indeterminates. The word 'indeterminate' was selected after considerable discussion, because the words 'neutral' or 'inert' already possess a special meaning as applied to paint technology. The committee takes this occasion to emphatically state that in adopting this tentative classification, the words 'inhibitive' and 'stimulative' as used by them up to the present time apply only to the results obtained in the water tests, and the inference that the results obtained have decided which class the pigment will fall into when made into a paint with the usual vehicles and used as a protective coating on iron and steel, is not justified. In order to make this point quite clear, it has been agreed by the committee to qualify the classification so as to speak of the various materials tested as 'water stimulative' or 'water inhibitive.'

"As a result of the preliminary tests, it seems desirable

PLATE VIII.
 PROG. AM. SOC. TEST. MATS.
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 OF COMMITTEE D-1.

REPORT OF COMMITTEE D-1.

FOURTH ANNUAL INSPECTION, 1913					
H. A. Gardner.	W. H. Walker.	C. S. Neal.	G. D. White.	C. M. Chapman.	Average.
0.5	0.5	2.0	1.0	2.5	1.3
0.5	0.5	2.0	1.0	2.5	1.3
0.5	0.0	2.0	0.5	1.2	0.8
7.5	6.0	4.0	6.0	6.0	5.9
8.5	8.0	5.0	7.0	7.3	7.2
0.5	0.0	1.0	0.0	0.5	0.4
2.0	4.0	3.0	4.0	3.3	3.3
4.0	5.0	3.0	3.8	4.0	4.0
5.5	6.0	8.0	6.0	6.0	6.3
5.0	4.0	5.0	4.0	4.5	4.5
5.5	7.0	3.0	4.0	6.0	5.1
4.0	7.0	8.0	4.0	7.5	6.1
4.0	7.0	8.0	6.5	5.7	6.2
0.5	2.0	3.0	3.5	4.0	2.6
4.0	5.0	3.0	4.5	4.5	4.2
8.0	8.0	8.5	7.0	8.0	7.9
3.5	7.5	8.0	7.0	8.1	6.8
4.0	6.0	7.0	4.0	5.0	5.2
0.0	0.0	0.0	0.0	0.5	0.1
0.5	0.0	0.0	0.0	0.6	0.2
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	1.0	0.2
1.0	2.0	0.5	0.5	2.7	1.3
1.0	2.0	0.5	0.0	2.5	1.2
10.0	10.0	10.0	9.0	10.0	9.8
6.0	4.0	5.0	5.0	6.0	5.2
8.5	8.0	7.5	8.0	8.0	8.0
8.0	7.5	7.5	8.0	8.0	7.8
8.0	8.0	7.0	7.5	7.5	7.6
7.5	8.0	6.0	5.5	6.5	6.7
7.0	6.0	3.0	3.0	6.2	5.0
0.0	0.0	0.0	0.0	0.0	0.0
8.5	8.5	7.0	8.0	9.5	8.3
7.5	8.5	6.5	7.5	8.8	7.8
5.0	3.0	8.0	7.0	8.0	6.2
2.0	3.0	3.0	2.5	3.5	2.8
2.0	0.5	2.0	1.0	2.0	1.5
4.0	4.0	4.0	4.0	5.0	4.2
4.0	3.0	8.0	7.5	6.8	5.9
5.0	7.0	8.0	6.5	7.3	6.8
3.0	2.0	2.0	4.0	4.0	3.0
5.0	9.0	7.0	7.5	7.3	7.2
5.0	3.0	4.0	3.0	4.0	3.8
4.0	4.0	3.0	2.5	3.5	3.4
3.0	4.0	3.0	3.0	4.0	3.4
2.0	6.0	5.0	....	6.2	4.8
1.0	1.0	1.0	....	3.0	1.5
1.0	2.0	3.0	2.0	3.5	2.3

to the committee that a systematic investigation of the same pigments should be made under service conditions. The Paint Manufacturers' Association of the United States offered to erect a series of steel panels at Atlantic City and place them under the supervision and control of this Society. The panels were erected in the autumn of 1908."

The third annual inspection of the tests was made by members of the sub-committee on April 1, 1912, and the fourth annual inspection on April 16, 1913. In making the inspection, the usual system of ratings was followed, those paints which were giving the greatest protection from corrosion, presenting the best appearance and showing the greatest durability, being accorded the highest rating, No. 10, while those coatings which had entirely failed their intended purpose were given the rating No. 0. The intermediate ratings are indicative of the merits of the respective paints. The results of each inspection are given in Table I (Plate VIII), each inspector's rating for each paint being given, as well as the average rating of all the inspectors for each inspection.

Respectfully submitted on behalf of the sub-committee,

H. A. GARDNER,
Chairman.

SUPPLEMENTAL REPORT.

On account of the necessity of clearing the land, for building purposes, upon which now stands the steel test fence, an inspection of the panels was made on June 23, 1913, by the sub-committee to determine which panels should be reserved for future test. The paints which had failed in the test were marked for discontinuance. They are as follows: Nos. 1, 2, 3, 6, 7, 27, 28, 29, 30, 31, 32, 33, 45, 48, 222, 333, 777, 2000, 3000, 4000, 90, 100, 5555.

The panels facing the ocean on each of the three fences, representing the other paints, will be removed from the fence and placed for future exposure on Young's Million Dollar Pier, upon a test frame to be erected for the purpose. The expenses of the removal of the panels and their future installation will be met by an appropriation made by the Paint Manufacturers' Association of the United States.

H. A. G.

REPORT OF SUB-COMMITTEE E ON LINSEED OIL.

The sub-committee reports as follows:

After considering the reports of this sub-committee since its organization, it was decided to secure samples of oils pressed from seed grown in India and South America, to determine the specific gravity at 15°.5/15°.5 C., the iodine number, the saponification number, the acid number, and the refractive index on them, in order to ascertain whether these figures would fall within the limits of the tentative specifications recommended in 1909,¹ which were based on samples of North American oil. Accordingly, in addition to the samples already on hand, the following samples were secured:

Sample
No.

- 16.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., February 24, 1911, by A. H. Sabin. Bottled March 1, 1911. Argentine seed.
- 17.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily samples from August 25, 1911, to October 21, 1912, inclusive. Calcutta seed.
- 18.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily samples from October 23, 1911, to January 26, 1912, inclusive. Bombay seed.
- 19.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily samples from January 27, 1912, to March 30, 1912, inclusive. North American seed.
- 20.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily sample from April 1, 1912, to May 22, 1912, inclusive. North American seed.
- 21.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily samples from May 23, 1912, to June 24, 1912, inclusive. North American seed.
- 22.... Sample of linseed oil taken at the Atlantic Mill, National Lead Co., by A. H. Sabin. Composite daily samples from June 27, 1912, to July 3, 1912, inclusive. Calcutta seed.
- 23.... Sample of linseed oil taken at Spencer Kellogg & Sons, Hudson Heights, N. J., May 17, 1912, by a representative of the New York Federal Laboratory. South American seed.
- 28.... Sample of linseed oil taken at the Dean Works, American Linseed Co., August 4, 1911, by a representative of the New York Federal Laboratory. Calcutta seed.

¹ *Proceedings, Am. Soc. Test. Mats.*, Vol. IX, p. 164 (1909).

The samples were submitted to the members of the committee and several others, with the following circular letter in which the methods outlined are those of the 1909 report:

WORK OUTLINE FOR SUB-COMMITTEE E ON LINSEED OIL.

LINSEED OIL.

This committee has obtained a number of additional samples of linseed oil made from linseed of different origin which are ready to be sent out for testing.

Samples Nos. 17, 22, 28 are oil obtained from Calcutta seed. No. 18 is from Bombay seed, Nos. 16, 23 are from La Plata seed, and Nos. 19, 20, 21 from North American Seed. On these samples determine the specific gravity at 15°.5 C., the acid number, the iodine number (Hanus), the saponification number and the index of refraction, all by the methods given in report of the Sub-Committee on Linseed Oil in the proceedings of the Society for 1909.

With the results of this work will you please express your opinion on the advisability of including the Calcutta and Bombay oils with North American in a set of specifications, and whether you favor the drawing up of another set for oil obtained from South American seed.

Make also a hexabromide test. Samples Nos. 5, 6, 18, 20, and 23 are to be used for the determination of the hexabromides. We ask that you follow the method outlined herewith, but wish that if you are able to develop any modification which gives more reliable results, that you would report your findings.

Preparation of the free fatty acids:

"Boil 50 g. of the oil with 40 cc. of a solution of potassium hydroxide, specific gravity 1.4, and 40 cc. of alcohol in a porcelain dish on a water bath, with constant stirring until the soap becomes pasty. The soap is then dissolved in a liter of water and the solution boiled to evaporate the alcohol; this can be effected readily by replacing the water as it boils away. Next the soap is decomposed by means of diluted sulphuric acid. When by continued boiling the fatty acids have been obtained as a clear oily layer, free from solid particles floating on the aqueous liquid, the latter is drawn off by means of a siphon, and the fatty acids washed several times with hot distilled water until all the mineral acid has been removed. Since the fatty acids of lower molecular weight dissolve in hot water and may redden litmus paper, methyl orange should be used to test for the complete removal of the mineral acid. The dish containing the fatty acids is then placed on a water bath and warmed until the fatty acids are completely liquefied. The water and impurities will settle out, and the warm acids may then be poured through a dry plaited filter in a hot water funnel. The fatty acids thus obtained will be sufficiently dry for examination."

If time permits, prepare the fatty acids by Goldschmidt's method also, as follows, and then proceed with the determination:

"Boil 50 g. of the oil with 30 cc. of a solution of potassium hydroxide,

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200 g. of KOH in 300 cc. of H_2O , and 70 cc. of alcohol in a porcelain dish on the water bath with constant stirring, until the soap becomes pasty. The soap is then dissolved in a liter of water and the solution boiled to evaporate the alcohol. Transfer the soap to a separatory funnel and decompose with dilute sulphuric acid; add 150 cc. of ether and shake. Draw off the aqueous layer and wash the other layer free from mineral acid, using a strong solution of sodium chloride instead of water for this washing. Transfer the ether solution to a wide mouth stoppered flask, cool to below $25^{\circ} C.$, and add sufficient anhydrous sodium sulphate to thoroughly dry (generally from 35 to 50 g. will be sufficient). Insert stopper and let stand with frequent shaking, for about one hour. See that the temperature does not rise above $25^{\circ} C.$ Filter through a dry paper into another flask and drive off the ether by a current of dry hydrogen at a temperature not above $50^{\circ} C.$, which can be maintained by setting the flask in a bath of warm water."

To determine the percentage of hexabromides in the free fatty acids, take one gram of the sample and weigh into a stoppered flask, add 50 cc. of absolute ether, chill, add bromine drop by drop, being careful to keep the flask and contents between 4° and $6^{\circ} C.$, until an excess of bromine is shown by a permanent reddish brown color. Let stand in water between 4° and $6^{\circ} C.$ for thirty minutes, then filter and wash four times with 20 cc. of cold absolute ether. After the addition of the ether put the flask back into the ice water bath for a few minutes before filtering or centrifuging. Dry in a water bath, after the ether is removed continue drying for one hour and weigh. A centrifuge is of advantage if available.

P. H. Walker has found that after saponifying the oil from a paint, the iodine number of the oil is low, while that of the fatty acids from the same oil will be about normal. In view of this fact it is desirable to establish limits of the iodine value of the free fatty acids, so we ask that you determine it on the fatty acids prepared from the various oils.

BOILED OIL.

One of the requisites in dealing with this product is to have a definition. Will you not give us the benefit of your ideas on this subject, formulating a definition if possible, but at least letting us know what things you think ought to be included in the definition?

Samples Nos. 25, 27 and 29 are of the linoleate type, that is, the lead and manganese are combined with linseed oil alone. Nos. 24 and 26 are made by combining the lead and manganese with resin, and adding this resinate to the oil.

On these samples please determine the specific gravity, the iodine number (Hanus), the acid number, the saponification number, the percentage of ash and that of lead, calcium and manganese in the ash, and the unsaponifiable matter soluble in petroleum ether; if the time permits, also the percentage of hexabromides by the methods outlined for raw oil.

To determine the amount of lead, calcium and manganese, take 20 or more grams of the boiled oil and burn off in a silica or porcelain dish or dissolve out the lead and manganese in a separatory funnel with hydrochloric

or nitric acids. If ashing is followed, place the vessel on the floor of a hood, heat by an inclined flame until the oil burns. Remove the flame and allow the oil to burn as long as it will. Apply the inclined flame again until all of the volatile matter is consumed. Burn off the carbonaceous matter at as low a heat as possible; do not heat above a barely visible red. If convenient use a muffle. Dissolve the ash and make quantitative determinations of lead, manganese and calcium, describing methods used in reporting results.

GLENN H. PICKARD,
Chairman.

The analysts so far reporting are as follows:

1. Dean M. Jackman for S. S. Voorhees, Bureau of Standards, Washington, D. C.
2. E. W. Boughton, Bureau of Chemistry, Contracts Laboratory, Washington, D. C.
3. S. Ginsburg for P. H. Walker, Chief of Contracts Laboratory, Washington, D. C.
4. C. B. Mills for G. W. Thompson, Chief Chemist, National Lead Co., 129 York St., Brooklyn, N. Y.
5. H. A. Crown for G. H. Pickard, Chemist, American Linseed Co., 11099 Torrence Ave., Chicago, Ill.
6. H. C. Mougey for D. A. Kohr, Superintendent of Lowe Brothers Co., Dayton, Ohio.
7. E. W. Martin, Chemist, Midland Linseed Products Co., Minneapolis, Minn.
8. A. H. Gill, Massachusetts Institute of Technology, Boston, Mass.
9. Wm. R. Eipper for E. C. Holton, Chemist, Sherwin-Williams Co., Cleveland, Ohio.

RESULTS OF TESTS ON RAW LINSEED OIL.

The results reported on raw linseed oil are given in Table I.

Samples Nos. 16 and 23, which are from South American seed, each have an iodine value lower than specification limits, and therefore indicate the impossibility of including North and South American oils in one specification.

The new samples of North American seed, from another year's crop, give results which fall within the tentative specifications proposed by the sub-committee.

Examination of these results shows that, like samples Nos. 1, 2, 3 and 4, sample No. 16 has changed but slightly during the two years which have elapsed since bottling.

The oils from Calcutta and Bombay seed give results which agree closely with those from North American seed, except

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TABLE I.—RESULTS OF TESTS ON RAW LINSEED OIL.

SOUTH AMERICAN SEED.

SAMPLE No. 16.

Analyst.	Specific Gravity at 15°.5/15°.5 C.	Acid Number.	Saponifi- cation Number.	Refractive Index at 25° C.	Iodine Number, Hanus.
1.....	0.9325	1.26	191.0	1.4786	171.8
2.....	0.9332	1.42	193.4	1.4784	170.5
3.....	0.9330	1.40	190.0	1.4779	170.6
4.....	0.9323	1.37	189.8	1.4788	171.8
7.....	0.9320	1.54	191.4	1.4789	171.8
8.....	.....	1.81	192.9	.....	168.1
Average.....	0.9326	1.47	191.4	1.4785	170.8

SAMPLE No. 23.

1.....	0.9321	3.22	190.4	1.4787	173.2
2.....	0.9327	3.61	191.2	1.4784	171.6
3.....	0.9328	3.53	190.3	1.4773	172.8
4.....	.....	3.43	189.8	1.4787	171.9
5.....	0.9324	3.30	190.3	.....	172.9
6.....	0.9317	3.53	186.2	.....	174.5
7.....	0.9327	3.57	191.5	1.4788	174.9
8.....	.....	3.86	194.3	.....	168.9
9.....	0.9263 ^b	3.77	190.6	.....	170.0
Average.....	0.9315	3.54	190.5	1.4784	172.3

NORTH AMERICAN SEED.

SAMPLE No. 19.

Analyst.	Specific Gravity at 15°.5/15°.5 C.	Acid Number.	Saponifi- cation Number.	Refractive Index at 25° C.	Iodine Number, Hanus.
1.....	0.9356	1.68	191.3	1.4806	188.7
2.....	0.9360	1.76	194.4	1.4805	187.6
3.....	0.9360	1.64	189.8	1.4795	187.6
4.....	0.9346	1.65	190.2	1.4805	188.1
5.....	0.9355	1.51	191.2	.....	189.1
6.....	0.9353	1.68	192.6	.....	187.9
8.....	.....	2.08	195.3	.....	185.5
9.....	0.9308 ^a	2.32	193.6	.....	185.6
Average.....	0.9355	1.79	192.3	1.4803	187.5

SAMPLE No. 20.

1.....	0.9357	1.68	191.3	1.4805	188.9
2.....	0.9360	1.76	193.6	1.4806	185.8
3.....	0.9360	1.71	190.8	1.4791	187.5
4.....	0.9348	1.72	191.5	1.4803	187.5
5.....	0.9356	1.63	190.1	.....	185.7
6.....	0.9353	1.79	186.6	.....	189.0
7.....	0.9355	1.77	192.2	1.4811	188.6
8.....	.....	2.33	195.9	.....	186.1
9.....	0.9304 ^b	2.37	195.0	.....	185.2
Average.....	0.9356	1.86	191.9	1.4803	187.1

SAMPLE No. 21.

1.....	0.9353	2.38	191.4	1.4803	187.6
2.....	0.9357	2.52	192.4	1.4804	183.2
3.....	0.9354	2.47	190.8	1.4790	185.6
4.....	0.9345	2.45	190.9	1.4805	186.3
5.....	0.9350	2.27	190.7	.....	186.5
6.....	0.9353	1.52	187.3	.....	187.2
8.....	.....	3.08	194.8	.....	182.8
9.....	0.9297 ^b	3.05	195.6	.....	184.1
Average.....	0.9352	2.47	191.7	1.4801	185.4

^aSpecific gravity taken at 25°.5/25°.5 C. This value not used in computing average.^bSpecific gravity taken at 26°/26° C. This value not used in computing average.

TABLE I.—RESULTS OF TESTS ON RAW LINSEED OIL (*Continued*).

CALCUTTA SEED.

SAMPLE No. 17.

Analyst.	Specific Gravity at 15°.5/15°.5 C.	Acid Number.	Saponifi- cation Number.	Refractive Index at 25° C.	Iodine Number, Hanus.
1.....	0.9332	1.26	191.2	1.4794	179.8
2.....	0.9337	1.32	193.4	1.4795	179.4
3.....	0.9341	1.24	190.1	1.4785	178.1
4.....	0.9325	1.26	192.1	1.4792	178.5
5.....	0.9333	1.09	191.1	.....	178.4
6.....	0.9335	1.24	189.8	.....	179.2
8.....	.....	1.43	195.3	.....	176.3
Average.....	0.9334	1.26	191.9	1.4792	178.5

SAMPLE No. 22.

1.....	0.9333	1.82	191.2	1.4794	178.6
2.....	0.9338	2.07	191.9	1.4792	175.9
3.....	0.9341	2.00	191.7	1.4778	178.3
4.....	0.9323	1.94	190.9	1.4794	176.5
8.....	.....	2.25	194.8	.....	174.1
Average.....	0.9334	2.02	192.1	1.4790	176.7

SAMPLE No. 28.

1.....	0.9327	1.54	190.8	1.4793	178.1
2.....	0.9328	1.75	192.0	1.4791	176.2
3.....	0.9334	1.67	190.0	1.4785	178.4
4.....	0.9320	1.60	191.7	1.4790	177.8
5.....	0.9326	1.57	189.9	.....	179.3
6.....	0.9345	1.72	196.4	.....	178.8
7.....	0.9329	1.76	192.0	1.4794	178.2
9.....	0.9278 ^b	1.45	192.1	.....	175.6
Average.....	0.9330	1.63	191.9	1.4791	177.8

BOMBAY SEED.

SAMPLE No. 18.

Analyst.	Specific Gravity at 15°.5/15°.5 C.	Acid Number.	Saponifi- cation Number.	Refractive Index at 25° C.	Iodine Number, Hanus.
1.....	0.9334	1.12	190.7	1.4796	179.8
2.....	0.9340	1.20	193.0	1.4795	179.6
3.....	0.9342	1.11	192.8	1.4787	178.6
4.....	0.9327	1.03	190.9	1.4795	178.9
5.....	0.9333	1.08	191.0	.....	180.8
6.....	0.9335	1.16	192.3	.....	181.4
7.....	0.9341	1.12	195.0	1.4797	181.7
8.....	.....	1.40	194.0	.....	177.3
9.....	0.9289 ^a	1.78	193.8	.....	177.5
Average.....	0.9336	1.22	192.6	1.4794	179.5

^aSpecific gravity taken at 25°.5/25°.5 C. This value not used in computing average.^bSpecific gravity taken at 26°/26° C. This value not used in computing average.

with respect to the iodine number, which is a little lower. Two of the samples have iodine numbers below the minimum of 178 set by the tentative specifications. These results make it necessary to lower the minimum of 178 to 176, or to state that the specifications apply to oils from North American seed only. The latter course seems more advisable, and the sub-committee therefore recommends that the tentative specifica-

tions proposed in 1909, with the exception that there be no maximum limit to the iodine number, be adopted as standard by the Society, under the title of "Standard Specifications for the Purity of Raw Linseed Oil from North American Seed." The recommended methods of testing for the specified properties given in the report for 1909 are included in the specifications, which are appended to this report.¹

Hexabromide Precipitates.—Owing to the fact that it is possible to adulterate raw linseed oil with other vegetable oils

TABLE II.—PERCENTAGE OF HEXABROMIDES.

Sample No.	Analyst.	By Committee Method.	By Eibner's Method.
5.....	1	33.60	{ 49.00 48.80
	2	40.00	
	4	41.87	
	5	37.04	
6.....	1	35.60	{ 48.51 48.63
	2	39.00	
	4	44.45	
	5	37.90	
18.....	1	35.10	{ 51.04 50.70
	2	44.30	
	4	51.18	
	5	37.90	
20.....	1	34.60	{ 52.20 51.57
	2	46.30	
	4	48.84	
	5	38.10	
23.....	1	36.20	{ 48.60 48.49
	2	39.30	
	4	48.36	
	5	34.20	

to a considerable extent without detection, the sub-committee is also working to develop a test which will make this impossible. The determination of the hexabromides seemed to offer possibilities, so samples were sent out with the above circular letter outlining a method for the determination of the hexabromides on the free fatty acids of the oil. The results obtained in determining the hexabromides are given in Table II.

The obvious conclusion to be drawn from the results obtained by the use of the method outlined by the committee is that it is unreliable and must, therefore, be abandoned.

¹ In presenting these specifications the committee recommended the changes given on pp. 18-19. The specifications as amended appear on pp. 399-401.—ED.

We wish to draw especial attention to the results obtained by Mr. G. W. Thompson by the Eibner method for determining the insoluble hexabromides of linseed oil. Duplicates gave results agreeing very closely. In his report Mr. Thompson states that the method is, in his opinion, a most satisfactory one for this determination. This method is given in abstract at the end of this report (pages 393-398).

Your committee proposes to have this method used on other samples by several analysts during the coming year, in the hope that the results obtained will warrant our endorsement of the method and enable us to set limits for the percentage of insoluble hexabromides of pure linseed oil.

RESULTS OF TESTS ON BOILED LINSEED OIL.

The boiled oil samples tested are as follows:

Sample No.

- 24.... Sample of boiled linseed oil, resinat type, taken at the Dean Works, American Linseed Co., July 16, 1912, by a representative of the New York Laboratory of the Bureau of Chemistry. North American seed.
- 25.... Sample of boiled linseed oil, linoleate type, taken at the Dean Works, American Linseed Co., July 16, 1912, by a representative of the New York Laboratory of the Bureau of Chemistry. North American seed.
- 26.... Sample of boiled linseed oil, resinat type (so described), taken at the works of the Archer Daniels Linseed Oil Co., Minneapolis, August 21, 1912, by a representative of the Minneapolis Laboratory of the Bureau of Chemistry.
- 27.... Sample of boiled linseed oil, linoleate type, taken at the works of the Midland Linseed Products Co., Minneapolis, August 21, 1912, by a representative of the Minneapolis Laboratory of the Bureau of Chemistry.
- 29.... Sample of boiled linseed oil, linoleate type, taken at the Atlantic Mill, National Lead Co., January, 1913, by A. H. Sabin.

The results obtained by the several analysts are given in Table III.

These results are interesting as showing figures which are of value in the consideration of specifications for boiled linseed oil, and are particularly gratifying in the general agreement of the determinations of ash and of lead, manganese, and calcium, showing that there are several good methods for these determinations as described in the individual reports given below.

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TABLE III.—RESULTS OF TESTS ON BOILED LINSEED OILS.

SAMPLE No. 24. RESINATE.

Analyst.	Specific Gravity at 15°/15° C.	Iodine Number, Hanus.	Saponification Number.	Acid Number.	Refractive Index at 25° C.	Unsaturation Matter, Soluble in Petrolie Ether.	Ash, per cent.	Manganese, per cent. ¹	Lead, per cent. ¹	Calcium, per cent. ¹
1.....	0.9424	181.2	190.8	7.00	.....	0.360	0.354	0.0641	0.107	0.0192
2.....	0.9424	180.6	192.4	8.36	.....	1.113	0.370	0.0590	0.110	0.020
3.....	0.9429	181.6	192.5	8.04	1.4830 ^a	0.920	0.350	0.0610	0.094	0.011
4.....	0.9413	179.8	190.1	8.01	1.4836	0.950	0.365	0.0693	0.106	0.025
5.....	.....	182.6	189.3	8.11	.....	.....	0.387	0.0680	0.105	0.016
7.....	0.9430	181.9	191.0	8.44	1.4826	.....	0.368	.....	.....	.....
Aver...	0.9422	181.3	191.0	7.99	1.4831	0.836	0.366	0.0642	0.104	0.018

SAMPLE No. 25. LINOLEATE.

1.....	0.9471	178.1	191.1	5.32	.....	1.200	0.631	0.038	0.323	0.012
2.....	0.9468	182.2	193.3	6.34	.....	0.810	0.590	0.035	0.370	0.030
3.....	0.9473	180.2	193.2	6.30	1.4835 ^a	0.740	0.620	0.041	0.330	0.019
4.....	0.9462	174.9	190.8	6.40	1.4829	0.790	0.678	0.046	0.392	0.035
5.....	.....	180.6	193.0	7.18	.....	.....	0.682	0.041	0.445	0.020
7.....	0.9488	177.2	192.0	6.51	1.4853	.....	0.631	.....	.....	.....
Aver...	0.9472	178.9	192.2	6.34	1.4841	0.885	0.642	0.040	0.372	0.0232

SAMPLE No. 26. RESINATE.

1.....	0.9359	183.4	184.2	6.16	.....	2.59	0.177	0.0255	0.055	0.015
2.....	0.9358	182.3	186.2	7.16	.....	4.39	0.170	0.0180	0.060	0.020
3.....	0.9358	184.6	185.7	6.90	1.4820 ^a	4.31	0.210	0.0260	0.044	0.013
4.....	0.9348	182.0	187.7	6.73	1.4813	3.86	0.196	0.0329	0.071	0.017
5.....	.....	183.7	186.0	6.80	.....	.....	0.197	0.0270	0.053	0.013
7.....	0.9359	182.6	184.4	7.05	1.4821	.....	0.191	.....	.....	.....
Aver...	0.9356	183.1	185.7	6.80	1.4820	3.79	0.190	0.0259	0.0566	0.016

SAMPLE No. 27. LINOLEATE.

1.....	0.9394	187.5	191.3	5.74	.....	0.15	0.225	0.046	0.055	0.008
2.....	0.9395	187.0	192.2	6.25	.....	0.90	0.200	0.035	0.060	0.030
3.....	0.9393	188.5	192.2	5.60	1.4820 ^a	0.76	0.230	0.051	0.047	0.017
4.....	0.9381	185.1	192.9	5.69	1.4816	0.80	0.242	0.054	0.053	0.014
5.....	.....	187.9	191.0	5.88	.....	.....	0.239	0.049	0.058	.....
7.....	0.9400	184.3	191.6	6.08	1.4870	.....	0.236	.....	.....	.....
Aver...	0.9393	186.7	192.0	5.87	1.4843	0.65	0.228	0.047	0.055	0.017

SAMPLE No. 29. LINOLEATE.

1.....	0.9439	180.1	190.4	4.34	.....	0.19	0.586	0.049	0.212	0.006
2.....	0.9436	179.4	190.5	5.67	.....	0.85	0.580	0.051	0.320	0.030
3.....	0.9438	181.9	192.2	4.57	1.4825 ^a	0.73	0.580	0.051	0.270	0.025
4.....	0.9425	179.1	191.7	5.08	1.4822	0.62	0.591	0.055	0.339	0.024
5.....	.....	180.4	192.3	5.24	.....	.....	0.613	0.053	0.312	0.012
7.....	0.9452	180.0	194.3	5.08	1.4829	.....	0.593	.....	.....	.....
Aver...	0.9440	180.1	191.9	5.00	1.4825	0.597	0.590	0.0518	0.290	0.019

^a These values are Refractive Index at 20° C. and are omitted from the averages.¹ Calculated in some cases from oxides reported.

The following are individual reports from some of the analysts referred to above:

REPORT OF ANALYST 1.—DEAN M. JACKMAN.

MR. GLENN H. PICKARD,

April 30, 1913.

Chairman, Sub-Committee E on Linseed Oil.

My dear Mr. Pickard:

I enclose tabulation (Tables IV, V and VI) of the results obtained on samples of boiled linseed oil sent with your letter of January 25. The methods used were in accordance with the instructions contained in the printed circular and require no special comment, except that as no muffle was available for ashing the oil, the final carbonaceous matter was burnt off over a Bunsen burner and it is probable that the results are somewhat low due to loss of lead.

TABLE IV.—CONSTANTS OF RAW LINSEED OILS, DETERMINED BY
DEAN M. JACKMAN.

Source of Oil.	Sample No.	Lab. No.	Saponification Number.	Iodine Number, Hanus.	Acid Number.	Specific Gravity at		Refractive Index with Zeiss Butyrorefractometer at 25° C.
						15° C.	25° C.	
La Plata.....	16	2202	191.0	171.0	1.40	0.9324	0.9279	1.4786
			191.1	172.4	1.12	0.9325	0.9278	
			191.0	172.0				
Calcutta.....	17	2203	191.3	179.9	1.40	0.9286	1.4794
			190.9	179.8	1.12	0.9332	0.9286	
			191.1	179.8	1.26			
Bombay.....	18	2204	191.4	179.6	1.12	0.9334	0.9288	1.4796
			190.0	180.0	1.12	0.9334	0.9288	
			190.7	179.8	1.12			
North America	19	2205	191.2	188.4	1.68	0.9357	0.9311	1.4806
			191.5	189.1	1.68	0.9355	0.9309	
			191.3	188.7	1.68	0.9356	0.9310	
North America	20	2206	191.6	188.4	1.68	0.9356	0.9309	1.4805
			191.0	189.4	1.68	0.9358	0.9311	
			191.3	188.9	1.68	0.9357	0.9310	
North America	21	2207	191.8	187.3	2.52	0.9354	0.9307	1.4803
			191.0	188.3	2.24	0.9352	0.9307	
			191.4	187.6		0.9353		
Calcutta.....	22	2208	191.6	178.6	1.68	0.9334	0.9288	1.4794
			190.7	178.8	1.96	0.9332	0.9288	
			191.2	178.5				
La Plata.....	23	2209	191.2	178.6	1.82	0.9333		1.4787
			190.3	172.6	3.36	0.9322	0.9275	
			190.6	173.7	3.08	0.9320	0.9276	
Calcutta.....	28	2214	190.4	173.4		0.9321		1.4793
			190.4	173.2	3.22			
			190.5	178.1	1.40	0.9282	
			191.0	178.2	1.68	0.9327	0.9281	
			190.8	178.1	1.54			

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It is probable that such loss could have been avoided if muffle was employed and carbonaceous matter burnt off at a very low red heat. It was therefore necessary to determine lead on a 50-g. sample by boiling for an hour with a 10-per-cent solution of HCl and washing the oil several times with H₂O in a separating funnel.

On account of the small size of sample it was not possible to check this determination, but it is probable that one hour's boiling is not always sufficient to insure complete removal of all the metallic oxides.

It would be of great advantage if all the oxides could be determined in the ash and it is believed that this would be possible provided precautions are taken to prevent loss of lead.

I want to express my appreciation of the careful work done by Dean M. Jackman of this laboratory on all the samples of oil covered by this year's report.

Very truly yours,

S. S. VOORHEES.

TABLE V.—PERCENTAGES OF INSOLUBLE HEXABROMIDES, DETERMINED BY DEAN M. JACKMAN.

Sample No.	5	6	18	20	23
Laboratory No.	2200	2201	2204	2206	2209
	33.2	35.2	32.8	33.8	41.1
	33.9	36.1	37.5	35.3	31.4
Hexabromides Found	33.6	35.6	35.1	34.5	36.2

TABLE VI.—PROPERTIES OF BOILED LINSEED OIL, DETERMINED BY DEAN M. JACKMAN.

Sample No.	Lab. No.	Type of Oil.	Specific Gravity at 15° C.	Iodine Number, Hanus.	Acid Number.	Saponification Number.	Ash, per cent.	Unsataponifiable Matter, per cent.	Metallic Oxides in Oil Determined:		
									By Extraction with Acid.		On Ash.
									PbO, per cent.	CaO, per cent.	Mn ₂ O ₃ , per cent.
24	2210	Resinate	0.9425	181.4	7.00	190.6	0.357	0.29	0.1123	0.0272	0.0876
			0.9423	181.1	7.00	191.1	0.351	0.44	0.1182	0.0266	0.0907
			0.9424	181.2	7.00	190.8	0.354	0.36	0.1152	0.0269	0.0891
25	2211	Linoleate	0.9471	177.7	5.32	190.8	0.631	0.19	.....	0.0105	0.054
			0.9471	178.6	5.32	191.4	0.632	0.05	0.348	0.0244	0.053
				178.1	5.32	191.1	0.6315	0.12	0.348	0.0174	0.053
26	2212	Resinate	0.9358	183.6	5.88	184.1	0.179	2.34	0.058	0.0232	0.035
			0.9359	183.2	6.44	184.2	0.175	2.84	0.061	0.0188	0.036
				183.4	6.16	184.1	0.177	2.59	0.060	0.0210	0.035
27	2213	Linoleate	0.9395	187.4	5.60	191.2	0.227	0.19	0.053	0.008	0.065
			0.9393	187.5	5.88	191.4	0.223	0.12	0.065	0.015	0.063
				187.4	5.74	191.3	0.225	0.15	0.059	0.012	0.064
29	2215	Linoleate	0.9439	180.4	4.20	190.2	0.588	0.18	0.239	0.005	0.069
			0.9439	179.9	4.48	190.6	0.585	0.21	0.219	0.013	0.069
				180.1	4.34	190.4	0.5865	0.19	0.229	0.009	0.069

REPORT OF ANALYST 2.—E. W. BOUGHTON.

METHODS USED FOR THE DETERMINATION OF LEAD, MANGANESE
AND CALCIUM.

Twenty to thirty grams of oil were ashed at a dull red heat. The ash was dissolved in warm HNO_3 and H_2O_2 . After cooling, about 25 cc. of 3-per cent H_2O_2 solution was added and a slight excess of NH_4OH . The solution was kept fairly cool, not above 35°C . The precipitated peroxides of lead and manganese were filtered off and washed, then dissolved in warm HNO_3 and H_2O_2 , and the precipitation with H_2O_2 and NH_4OH repeated. After

TABLE VII.—REPORT OF WORK ON RAW LINSEED OILS, BY E. W. BOUGHTON.

Contract No.	Sample No.	Specific Gravity at $15^\circ.5/15^\circ.5 \text{ C}$.	Acid Number.	Iodine Number, Hanus.	Saponification Number.	Refractive Index at 25°C .
		A = 50 cc. Plummet. B = 25 cc. Pyknometer.				
15862	16	A.....0.9331	1.43	173.1 ^a	193.5	1.4780
		B.....0.9333	1.42	170.2	193.2	1.4788
		Aver.....0.9332	1.42	170.5	193.4	1.4784
15863	17	A.....0.9338	1.32	178.5	193.2	1.4790
		B.....0.9335	1.32	180.2	193.6	1.4800
		Aver.....0.9337	1.32	179.4	193.4	1.4795
15864	18	A.....0.9341	1.21	180.0	193.6	1.4792
		B.....0.9339	1.20	179.2	192.4	1.4798
		Aver.....0.9340	1.20	179.6	193.0	1.4795
15865	19	A.....0.9360	1.76	187.6	194.8	1.4800
		B.....0.9359	1.76	187.6	194.0	1.4810
		Aver.....0.9360	1.76	187.6	194.4	1.4805
15866	20	A.....0.9359	1.76	185.7	193.5	1.4801
		B.....0.9361	1.76	185.8	193.6	1.4810
		Aver.....0.9360	1.76	185.8	193.6	1.4806
15867	21	A.....0.9359	2.53	183.9	192.6	1.4800
		B.....0.9355	2.52	182.4	192.1	1.4808
		0.9357	2.52	183.2	192.4	1.4804
15868	22	A.....0.9340	2.08	175.2	192.3	1.4785
		B.....0.9336	2.06	176.6	191.6	1.4798
		Aver.....0.9338	2.07	175.9	191.9	1.4792
15869	23	A.....0.9327	3.62	171.4	190.8	1.4780
		B.....0.9326	3.60	171.8	191.6	1.4787
		Aver.....0.9327	3.61	171.6	191.2	1.4784
15874	28	A.....0.9335 ^a	1.76	176.0	192.6	1.4786
		B.....0.9329	1.75	176.4	191.4	1.4796
		B.....0.9327	1.75	176.2	192.0	1.4791
		Aver.....0.9328	1.75	176.2	192.0	1.4791

^aOmitted from average.

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filtering and washing a second time, the filtrates were united, and the calcium precipitated therein as oxalate, then weighed as oxide as usual. The lead and manganese peroxides were dissolved on the filter and the solution made up to 250 cc. in a graduated flask. Two hundred cubic centimeters were pipetted out for lead determination, which was made by adding H_2SO_4 , evaporating to fumes, finally weighing the $PbSO_4$ on a Gooch crucible as usual. Twenty-five cubic centimeters were pipetted out for manganese, which was determined by the bismuthate method. The separation with H_2O_2 and NH_4OH works nicely when considerable calcium is present. The amount of calcium in the present samples was so small that the lead could probably have been separated directly as $PbSO_4$, but the manganese would subsequently have to be removed. The advantage of the method lies in the fact that H_2S or $(NH_4)_2S$ is not used. Two precipitations are necessary, as some calcium is occluded.

TABLE VIII.—REPORT OF WORK ON IODINE NUMBERS AND HEXABROMIDE DETERMINATIONS ON FATTY ACIDS OF RAW LINSEED OIL, BY E. W. BOUGHTON.

Contract No.	Sample No.	Method of Precipitation of Fatty Acids.	Experiment No.	Iodine Number of Fatty Acids, Hanus.			Hexabromides of Fatty Acids, per cent.		
						Av.			Av.
15860	5	A	A-1	189.2	187.8	188.5	39.3	40.6	40.0
15860	5	B	B-1	186.1	187.5	186.8	39.0	38.4	38.7
15861	6	A	A-1	186.9	184.2	185.6	37.4	40.5	39.0
15861	6	B	B-1	184.2	182.4	183.3	35.5	34.8	35.2
15864	18	A	A-1	182.7 ^a	181.6 ^a	.....	43.5	45.1	44.3
				187.9	190.0	189.0			
15864	18	B	B-1	182.3 ^a	183.1 ^a	.....	32.3 ^a	39.1	39.6
				188.9	189.4	189.2	40.1		
15866	20	A	A-1	195.0	193.8	194.4	45.9	46.6	46.3
15866	20	B	B-1	176.8	171.9	174.4			
		B	B-2	194.5	195.5	195.0	38.9	38.4	38.7
							43.5	41.1	42.3
15869	23	A	A-1	179.8 ^a	179.5 ^a	.....	38.4	40.2	39.3
				181.3	182.0	181.7			
15869	23	B	B-1	168.2 ^a	170.6 ^a	.....		
				174.2	172.5	173.4			
15869	23	B	B-2	173.6	176.3	175.0	41.4	36.9	39.2
		B	B-3	181.1 ^a	189.2 ^a	.....		
				182.4	182.2	182.3	38.7	36.6	37.7

^aOmitted from average; believed to be erroneous.

A—Oil saponified, fatty acids separated, boiled with distilled water until free from mineral acids, and filtered through filter paper.

B—Goldschmidt's method, using U. S. P. ether.

TABLE IX.—REPORT OF WORK ON BOILED LINSEED OIL, BY
E. W. BOUGHTON.

Contract No.	Sample No.	Specific Gravity at 15°/15° C.	Iodine Number, Hanus.	Acid Number.	Saponification Number.	Ash, per cent.	Lead, per cent.	Manganese, per cent.	Calcium, per cent.	Unsaponifiable Matter, per cent.		Resin Test.	
										Solvent Ether, U. S. P.	Petroleum Ether, 45°-60° C.	Liebermann-Storch Method.	Halpen and Hicks Method.
15870	24	0.9411 ^a	180.5	8.30	205.4 ^a	0.38	0.11	0.059	0.02	1.63	1.13	present	present
		0.9423	180.7	8.41	191.5	0.36	...	0.058	0.02				
		0.9425	...	...	192.5	...	...	...	...
		...	...	...	193.2	...	...	...	...
		Av. 0.9424	180.6	8.36	192.4	0.37	0.11	0.059	0.02				
15871	25	0.9469	176.3 ^a	6.25	193.5	0.60	0.35	0.032	0.03	1.30	0.81	not detected	not detected
		0.9467	176.5 ^a	6.42	193.1	0.57	0.38	0.037	0.03				
		...	182.3	...	...	...	...	...	...
		...	181.9	...	...	...	...	...	...
		Av. 0.9468	182.2	6.34	193.3	0.59	0.37	0.035	0.03				
15872	26	0.9364 ^a	182.3	7.15	186.2	0.17	0.06	0.017	0.04	4.73	4.39	not detected	not detected
		0.9357	182.2	7.16	185.1	0.17	0.05	0.018	0.02				
		0.9359	...	...	...	...	...	...	0.01
					
		Av. 0.9358	182.3	7.16	186.2	0.17	0.06	0.018	0.02				
15873	27	0.9392	186.2	6.16	192.6	0.22	0.07	0.040	0.04	0.96	0.90	not detected	not detected
		0.9397	187.7	6.23	191.7	0.18	0.06	0.029	0.01				
		...	...	6.36	...	...	...	...	0.03
					
		Av. 0.9395	187.0	6.25	192.2	0.20	0.06	0.035	0.03				
15875	29	0.9434	178.7	5.41	190.5	0.59	0.32	0.049	0.03	1.10	0.85	not detected	not detected
		0.9438	180.1	5.74	190.5	0.57	0.31	0.052	0.03				
		...	...	5.87	...	...	...	...	...
					
		Av. 0.9436	179.4	5.67	190.5	0.58	0.32	0.051	0.03				

^aOmitted from average; believed to be erroneous.

The figures for calcium are uncertain owing to the smallness of the samples. At least one quart should be sent to each analyst.

For the determination of unsaponifiable the Boemer method was followed, using one-fifth the prescribed quantities and omitting the second treatment with the alcoholic KOH. Where petroleum ether was used it was necessary to add alcohol to break up the emulsions.

REPORT OF ANALYST 3.—S. GINSBURG.

The figures for calcium, given in Table XI, are uncertain owing to the small size of the samples. The methods for the determination of the lead, manganese and calcium were the same as given in Mr. Boughton's report.

The unsaponifiable for boiled oils, Table XI, was determined by the Boemer method, using one-fifth the prescribed quantities and omitting the second treatment with alcoholic KOH. It was found necessary to use alcohol to break up the emulsions formed when petroleum ether was used as the extracting material.

It will be noted that the ratio of unsaponifiable extracted with ether to unsaponifiable extracted with petroleum ether = 1.54, 1.55, 1.53, and 1.59, respectively, in samples Nos. 24, 25, 27 and 29. This fact led to the determination of the unsaponifiable in a sample of commercial boiled oil.

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The Boehmer method was followed exactly. When petrolic ether was used for the extraction, it was found necessary to add alcohol in order to break up the emulsions that formed.

ETHER EXTRACT, 100 GRAMS OF OIL.	PETROLIC ETHER EXTRACT, 100 GRAMS OF OIL.
1.05 per cent	0.65 per cent
1.07 "	0.68 "
Aver. = 1.06 "	Aver. = 0.67 "
Ether Extract	
Petrolic Ether Extract = 1.58	

Upon treatment of the unsaponifiable extracted by ethyl ether with petrolic ether it was found that white, flocculent residue remained undissolved.

TABLE X.—REPORT OF WORK ON LINSEED OILS, BY S. GINSBURG.

Contract No.	Sample No.	Specific Gravity at 15° 5/15° 5 C., 25-cc. Pyknometer.	Acid Number.	Iodine Number, Hanus.	Saponification Number.	Refractive Index at 25° C.
15862	16	0.9330	1.39	170.9	190.1	1.4779
		0.9329	1.41	170.3	189.8	
		Av.....0.9330	1.40	170.6	190.0	
15863	17	0.9339	1.23	177.9	190.2	1.4785
		0.9342	1.24	178.3	190.0	
		Av.....0.9341	1.24	178.1	190.1	
15864	18	0.9345	1.12	178.6	191.9	1.4787
		0.9338	1.09	178.6	193.6	
		Av.....0.9342	1.11	178.6	192.8	
15865	19	0.9357	1.61	187.4	189.7	1.4795
		0.9363	1.66	187.7	189.8	
		Av.....0.9360	1.64	187.6	189.8	
15866	20	0.9361	1.71	187.6	190.9	1.4791
		0.9359	1.71	187.4	190.6	
		Av.....0.9360	1.71	187.5	190.8	
15867	21	0.9354	2.48	185.2	191.5	1.4790
		0.9354	2.46	186.0	190.1	
		Av.....0.9354	2.47	185.6	190.8	
15868	22	0.9338	2.01	177.8	191.2	1.4778
		0.9343	1.99	178.8	192.2	
		Av.....0.9341	2.00	178.3	191.7	
15869	23	0.9330	3.49	173.1	190.6	1.4773
		0.9326	3.56	172.5	189.9	
		Av.....0.9328	3.53	172.8	190.3	
15874	28	0.9336	1.68	178.3	190.2	1.4785
		0.9332	1.66	178.4	189.7	
		Av.....0.9334	1.67	178.4	190.0	

TABLE XI.—REPORT OF WORK ON BOILED LINSEED OIL, BY S. GINSBURG.

Contract No.	Sample No.	Specific Gravity at 15° 6/15° C.	Iodine Number, Haas.	Acid Number.	Saponification Number.	Ash, per cent.	Lead, per cent.	Manganese, per cent.	Calcium, per cent.	Resin Test.				Refractive Index at 20° C.
										Unsapo- nifiable, per cent.	Soluble in Ether.	Soluble in Petrolic Ether, 45-60° C.	Liebermann- Storch Method.	Halpen and Hicks Method.
15870	24	0.9428	181.3	8.05	192.0	0.35	0.096	0.064	0.011	1.42	0.92	present	present	1.4830
		0.9430	181.8	8.03	193.0	0.35	0.092	0.057						
		Av. 0.9429	181.6	8.04	192.5	0.35	0.094	0.061						
15871	25	0.9474	180.0	6.30	193.3	0.62	0.33	0.066 ^a	0.019	1.15	0.74	not detected	not detected	1.4835
		0.9471	180.3	6.30	193.1	0.62	0.32	0.041						
		Av. 0.9473	180.2	6.30	193.2	0.62	0.33	0.041						
15872	26	0.9357	184.0	6.90	185.3	0.21	0.046	0.024	0.013	4.66	4.31	not detected	not detected	1.4820
		0.9359	185.2	6.90	186.1	0.21	0.041	0.027						
		Av. 0.9358	184.6	6.90	185.7	0.21	0.044	0.026						
15873	27	0.9392	189.0	5.60	192.2	0.23	0.042	0.054	0.017	1.16	0.76	not detected	not detected	1.4820
		0.9394	188.0	5.60	192.1	0.23	0.051	0.048						
		Av. 0.9393	188.5	5.60	192.2	0.23	0.047	0.051						
15875	29	0.9439	181.7	4.72	192.5	0.58	0.27	0.050	0.025	1.16	0.73	not detected	not detected	1.4825
		0.9437	182.1	4.42	191.8	0.58	0.27	0.051						
		Av. 0.9438	181.9	4.57	192.2	0.58	0.27	0.051						

^a Omitted from average; believed to be erroneous.

REPORT OF ANALYST 4.—C. B. MILLS.

The method finally adopted for the determination of lead, manganese and calcium in boiled oils (Table XII) was to first get the oxides of the metals in the oil by ashing not less than 50 g. in a large porcelain dish, taking precaution to prevent any loss of lead by volatilization or the ash by dusting. Having gotten the ash practically free from carbon, the residue was treated with HCl and HNO₃ acids and the solution together with any insoluble matter was transferred to a small beaker, about 5 cc. one-to-one H₂SO₄ added and the solution taken to fumes of SO₃; allowed to cool and then diluted with water to about 100 cc. This warm solution was set aside for an hour or two and then 100 cc. of alcohol was added and the whole allowed to stand for one hour more. It was found by this treatment that the lead, free from calcium, could be easily and completely removed. The lead sulphate was dissolved in hot ammonium acetate to get rid of any SiO₂, etc., and the lead precipitated as chromate in filtrate, filtered and weighed in gooches as usual.

The filtrate from the insoluble sulphate, etc., containing the manganese and calcium, was diluted to 250 cc., and 100 cc. taken for manganese and 100 cc. for calcium.

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TABLE XII.—RESULTS OF TESTS ON RAW AND BOILED LINSEED OILS, BY C. B. MILLS.

Oil No.	Iodine Number, Hanus.	Specific Gravity at 15° C.	Acid Number.	Refractive Index at 25° C.	Saponification Number.
5.....	177.6	0.9317 (Check 0.9315)	5.44	1.4789	189.5
6.....	177.7	0.9326	2.31	1.4790	190.2
16.....	171.8	0.9323	1.37	1.4788	189.8
17.....	178.5	0.9325	1.26	1.4792	192.1
18.....	178.9	0.9327	1.03	1.4795	190.9
19.....	188.1	0.9346	1.65	1.4805	190.2
20.....	187.5	0.9348	1.72	1.4803	191.5
21.....	186.3	0.9345	2.45	1.4805	190.9
22.....	176.5	0.9323	1.94	1.4794	190.9
23.....	171.9	0.9311-0.9312	3.43	1.4787	189.8
24 (Boiled)	179.8	0.9413	8.01	1.4836	190.1
25 (Boiled)	174.9	0.9402	6.40	1.4829	190.8
26 (Boiled)	182.0	0.9348	6.73	1.4819	187.7
27 (Boiled)	185.1	0.9381	5.69	1.4816	192.9
28.....	177.8	0.9320	1.60	1.4790	191.7
29 (Boiled)	179.1	0.9425	5.08	1.4822	191.7

TABLE XII (Continued).

Oil No.	Ash, per cent.	Mn, per cent.	Pb, per cent.	Ca, per cent.	Unsaponifiable Matter in Petrolic Ether, per cent.
24 (Boiled)	0.365	0.0693	0.1060	0.025	0.95
25 (Boiled)	0.678	0.0459	0.3920	0.035	0.79
26 (Boiled)	0.196	0.0329	0.0706	0.017	3.86
27 (Boiled)	0.242	0.0543	0.0529	0.014	0.80
29 (Boiled)	0.591	0.0556	0.3390	0.024	0.62

TABLE XIII.—HEXABROMIDE NUMBERS, BY C. B. MILLS.

By COMMITTEE METHOD. ¹		By "EIBNER'S METHOD."	
Oil No. 5.....	41.22 per cent	Oil No. 5.....	49.00 per cent
	43.18 "		48.80 "
	41.55 "		48.51 "
	41.56 "		48.63 "
" " 6.....	44.45 "	" " 18.....	51.04 "
" " 18.....	51.18 "	" " 20.....	50.70 "
" " 20.....	48.84 "	" " 20.....	52.20 "
" " 23.....	48.36 "	" " 20.....	51.57 "
		" " 23.....	48.69 "
		" " 23.....	48.49 "

¹ Fatty acids prepared by first of two methods described in circular letter.

The manganese was determined by the Volhard method, the 100-cc. portion being checked by ashing another 50-g. sample and determining the manganese directly on the whole ash without first removing lead, etc. The results agreed satisfactorily.

The determination of calcium was carried out as follows:

The solution was made alkaline with ammonia and treated with H_2S for about one-half hour to precipitate the manganese, iron, etc. These sulphides were filtered off and the filtrate boiled until free from excess of ammonium sulphide; it was then made slightly acid with HCl and the remaining sulphides and free sulphur oxidized with bromine. In order to make sure that last traces of manganese were removed, the solution was made slightly alkaline with ammonia and again treated with bromine and filtered. The calcium was precipitated as oxalate in the usual way. The precipitate was ignited in platinum crucible, converted to sulphate, and weighed.

REPORT OF ANALYST 5.—H. A. CROWN.

Method of Ashing.—The sample, in a silica dish, was carefully heated by an inclined flame until the oil burned. The flame was removed and the oil allowed to burn as long as it would. The dish was then placed in the forward part of a gas muffle-furnace, heated to a dull red heat. When all the volatile matter was driven off, the dish was moved farther back in the muffle until all the carbonaceous matter was burned off. The ash was broken up with a platinum wire to insure complete combustion.

TABLE XIV.—RESULTS OF TESTS ON RAW LINSEED OILS.
(H. A. CROWN).

Sample No.	Iodine Number, Hanus.	Saponification Number.	Specific Gravity at 15° C.	Acid Number.
17.....	178.4	191.1	0.9333	1.09
18.....	180.8	191.0	0.9333	1.08
19.....	189.1	191.2	0.9355	1.51
20.....	185.7	190.1	0.9356	1.63
21.....	186.5	190.7	0.9350	2.27
23.....	172.9	190.3	0.9324	3.30
28.....	179.3	189.9	0.9326	1.57

TABLE XV.—RESULTS OF TESTS ON FREE FATTY ACIDS.
(H. A. CROWN).

From Sample No.	Hexabromides.	Iodine Number, Hanus.
5.....	37.04	187.1
6.....	37.50	184.4
18.....	41.17	185.8
20.....	38.10	194.8
23.....	31.20	178.3

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Determination of Manganese.—Separate portions of about 30 g. of the oil were ashed as above outlined. The ash was dissolved in nitric acid, specific gravity 1.135, to which a little 3-per-cent hydrogen peroxide was added. This dissolves the ash completely and quickly. The solution was boiled to expel the excess peroxide, cooled and then diluted with water to 250 cc. For the determination of manganese, 50-cc. portions were taken, to which 15 cc. of concentrated nitric acid was added, making a nitric acid solution of approximately 1.135 specific gravity. From this point, the sodium bismuthate method was followed exactly as given in Blair's *Chemical Analysis of Iron*, Seventh Edition.

Determination of Lead and Calcium.—For the determination of lead and calcium, larger portions of the oil were taken, at least 50 g. The ash was dissolved in nitric acid and hydrogen peroxide as in the case of the determination of manganese, the entire solution being used for the determinations. Five cubic centimeters of concentrated sulphuric acid were added to the ash solution, which was then evaporated to white fumes. After cooling, about

TABLE XVI.—RESULTS OF TESTS ON BOILED LINSEED OILS (H. A. CROWN).

Sample No.	Iodine Number, Hanus.	Saponification Number.	Acid Number.	Percentage of			
				Ash.	Manganese.	Lead.	Calcium.
24.....	182.6	189.3	8.11	0.387	0.068	0.106	0.020
25.....	180.6	193.0	7.18	0.682	0.041	0.445	0.016
26.....	183.7	186.0	6.80	0.197	0.027	0.053	0.018
27.....	187.0	191.9	5.88	0.239	0.049	0.058	0.028
29.....	180.4	192.3	5.24	0.613	0.053	0.031	0.017

200 cc. of 50-per-cent alcohol was added and allowed to stand for 2 or 3 hours. Then the lead sulphate was filtered off and the filtrate saved for the determination of calcium. The washed precipitate was then dissolved in hot ammonium acetate, heated to boiling and the lead precipitated as chromate. The precipitate was collected in an alundum crucible, gently ignited and weighed.

The filtrate containing the calcium was made alkaline with ammonium hydroxide and the hot solution treated with hydrogen sulphide. The precipitated sulphides were filtered off, the filtrate boiled to expel the excess of ammonium sulphide, and then made acid with HCl and bromine added to oxidize the free sulphur. The solution was then made alkaline with ammonium hydroxide and the calcium precipitated from the boiling solution as oxalate.

NOTE.—Separate portions for manganese were taken because the muffle was too small to ash a larger quantity at one time. Where a large enough quantity can be ashed at one time, only one solution need be made for all three determinations, aliquot portions being taken.

REPORT OF ANALYST 7.—E. W. MARTIN.

June 19, 1913.

MR. G. H. PICKARD,

Chairman, Sub-Committee E on Linseed Oil.

Dear Sir:

We submit herewith our report on the samples of raw and boiled linseed oil received from your committee for analysis:

TABLE XVII.—RESULTS OF TESTS BY E. W. MARTIN.

Sample No.	1. Specific Gravity.		2. Turbidity and Fouts, per cent.	3. Breaking Tests.	4. Moisture and Volatile Matter, per cent.		5. Ash, per cent.
	At 15°.5 C.	At 25° C.			Loss.	Gain.	
5	0.9324	0.9282	Trace	No Break	0.140	.....	0.068
6	0.9342	0.9297	2.34	Break	0.145	.....	0.154
16	0.9320	0.9281	1.00	Break	0.075	.....	.....
18	0.9341	0.9298	Trace	No Break	0.051	.....	0.132
20	0.9355	0.9315	Trace	Break	0.146	.....	0.174
23	0.9327	0.9285	3.61	Break	0.046	.....	0.103
24	0.9430	0.9382	0.25	No Break	.....	0.521	0.368
25	0.9488	0.9454	Very turbid: 0.25	No Break	.....	0.366	0.651
26	0.9359	0.9313	Very turbid: 1.47	No Break	.....	0.50	0.191
27	0.9400	0.9358	0.85	No Break	.....	0.43	0.236
28	0.9329	0.9284	3.40	No Break	0.064	.....	.....
29	0.9452	0.9409	0.35	No Break	.....	0.651	0.593

In Table XVII are given the results of the tests for specific gravity, turbidity and fouts, breaking tests, moisture and volatile matter, and ash.

1. The specific gravity was determined with a 25-cc. gravity bottle. It has an attached thermometer and was standardized with pure water at 15°.5 C. and at 25° C.

2. The tests for turbidity and fouts were run on 50-cc. samples in tall form water-comparison tubes.

3. The breaking tests were made in a test tube, heating by direct flame.

4. The moisture and volatile matter was determined in an air oven heated by a gas flame but maintained at 100° C.

5. Ash—no comments.

In Table XVIII is given the percentage of oxygen absorption, using 10 g. of PbO passing through a 100-mesh screen.

In Table XIX are given the acid number, saponification number, the Liebermann-Storch test, refraction index at 25° C., and the iodine number.

You will note that the oxygen absorption on the various samples does not correspond with the iodine values of the same samples. We attribute this to an unevenness in the quality of the PbO in the oxygen absorption test, which we obtained from a sample we had in our laboratory, and to the fact that the distribution of the oil over the PbO was not uniform. We did not

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TABLE XVIII.—RESULTS OF TESTS BY E. W. MARTIN.

Sample No.	Oil.	Amount Taken, grams.	Increase in per cent in — hours.							
			8	24	31	48	56	74	96	105
5	Raw	0.6200	0.20	11.42	11.71	12.00	12.00	12.24	12.35	12.10
6	"	0.6685	0.63	11.84	12.60	12.89	12.90	13.13	13.22	12.90
16	"	0.6226	0.33	7.71	11.86	13.30	13.50	13.64	13.53	.....
18	"	0.6975	0.64	11.74	14.12	14.76	14.92	15.08	15.00	.....
20	"	0.6164	0.37	11.61	14.71	15.91	16.04	16.07	15.91	.....
23	"	0.6620	1.34	11.88	13.96	14.16	14.06	.....	.....	.....
24	Boiled	0.7359	8.73	9.81	10.32	10.77	10.79	11.41	11.71	11.67
25	"	0.6400	8.48	9.62	10.04	10.50	10.67	11.14	11.33	11.28
26	"	0.6218	11.94	12.77	13.08	13.41	13.49	13.70	13.88	13.69
27	"	0.7300	10.17	11.31	11.80	12.26	12.42	12.81	13.11	12.94
28	Raw	0.6922	0.44	12.04	13.24	13.76	13.66	.....	.....	.....
29	Boiled	0.7094	8.06	9.43	9.92	10.43	10.70	11.23	11.58	11.51

TABLE XIX.—RESULTS OF TESTS BY E. W. MARTIN.

Sample No.	Acid Number.	Saponification Number.	Liebermann-Storch Test.		Refrac-Index at 25° C.	Iodine Number (Hanus).
			Resin.	Appearance.		
5	5.61	191.4	0	Green	1.4795	177.6, 177.4
6	2.36	192.4	0	Brown and Yellow	1.4796	180.2, 180.3
16	1.54	191.4	0	Green	1.4789	171.8, 171.7
18	1.12	195.0	0	Green	1.4797	181.4, 182.0
20	1.77	192.2	0	Green	1.4811	188.5, 188.6
23	3.57	191.5	0	Green	1.4788	175.0, 174.7
24	8.44	191.0	very strong	Violet to Brown	1.4826	181.9, 181.8
25	6.51	192.0	0	Brown	1.4853	176.9, 177.5
26	7.05	184.4	weak	Violet to Brown	1.4821	182.5, 182.7
27	6.08	191.6	0	Brown	1.4870	184.1, 184.6
28	1.76	192.0	0	Green	1.4794	178.2, 178.2
29	5.08	194.3	0	Brown	1.4829	180.4, 179.6

test out all of the samples because some of them were not large enough for our purpose, and we omitted some of the determinations because of lack of time to complete them.

These tests were made by our chemist, Mr. E. W. Martin.

Yours very truly,

MIDLAND LINSEED PRODUCTS CO.

E. C. BISBEE,

Vice-President.

Note by Mr. Pickard: These results are from the tests called for in the 1909 report of our committee. See *Proceedings*, Vol. IX, pp. 141 ff. (1909).

EIBNER'S METHOD.¹

DESCRIPTION OF NEW METHOD FOR DETERMINATION OF HEXABROMIDE NUMBER OF LINSEED OIL FATTY ACIDS.

The determination of the hexabromide number is preceded by the preparation of free fatty acids.

1. *Preparation of Pure Linseed Oil Fatty Acids.*—Three and one-half grams of the linseed oil are weighed into each of three round-bottom evaporating dishes of about 220-cc. capacity. Then, 45 cc. of one-half-normal alcoholic potash are added in each case and the dishes are placed on the water bath. This is brought slowly to boiling. The oil is frequently stirred with a glass rod, flattened at the end. By this method, the saponification is better and more quickly accomplished.

The alcoholic potash is prepared as follows: 28 g. of solid pure caustic alkali are placed in a 1-liter measuring cylinder and dissolved in from 30 to 40 cc. of distilled water; then, 97-per-cent ethyl alcohol is added, to make the volume 1 liter. The solution is allowed to stand for 2 or 3 days to settle out any cloudiness due to potassium carbonate. This potash solution is best kept in a brown bottle, stoppered with a rubber stopper.

The water bath is not warmed until the evaporating dishes are filled. The saponification process begins slowly and gradually, so that the alcoholic soap solution does not crawl up to the rim of the evaporating dishes, thereby causing losses. The contents of the dishes are evaporated to dryness, with constant stirring and breaking up of the nearly dry soaps. In this way, the alcohol is completely removed. This whole operation of saponification and evaporation will take from 1 to 1½ hours. The resulting product will be a light yellow, agreeable smelling soap powder. The soap which first comes to dryness is mixed with 50 cc. of hot water, and dissolved on the boiling water bath. This requires about 5 minutes. This soap solution is added to the soap which next comes to dryness, and the first evaporating dish is rinsed out with water. Finally, this solution is added to the soap which last comes to dryness. The whole soap solution is cooled off somewhat and poured into a 1-liter separatory funnel, graduated at 180 cc. and 340 cc. The volume of the soap solution must now amount to 180 cc. and must not be any greater. The light yellow soap solution, which is absolutely clear in a warm state, is now cooled down to the temperature of tap water, whereby it becomes slightly cloudy. By the addition of 20 cc. of five-normal sulphuric acid, the linseed fatty acids are freed, and float on top of the liquid. They have an agreeable, characteristic odor and are, in the beginning, precipitated in an opaque, white form. After a few seconds, the emulsion disappears. The acids then are plainly yellow. The contents of the separatory funnel are now thoroughly shaken with 140 cc. of ether (second mark at 340 cc.), during which operation

¹Translation of part of Eibner's article in the *Farben-Zeitung*, November 23, 1912 (No. 8).

the cock is opened at least once to avoid excessive pressure. After 5 minutes, the aqueous solution is drawn off as much as possible, the yellow ether solution of fatty acids is gently rotated and allowed to stand for a minute. After this operation, a little more water will settle in the lower part of the separatory funnel, and is removed. After adding 70 g. of anhydrous Glauber's salt, the fatty-acid solution is allowed to stand over night in the separatory funnel.

The detailed operation is as follows: Saponification should not be started until the afternoon. After setting free the fatty acids with sulphuric acid, 100 cc. of ether are first used for shaking out and allowed to stand. The aqueous solution is drawn off into a second separatory funnel, and then shaken out again with 40 cc. of ether. The combined ether solutions of fatty acids are then to be further treated as mentioned above.

The next forenoon, the recovery of the pure fatty acids is undertaken. For this purpose, a tared Erlenmeyer flask of 200-cc. capacity is used. The flask is stoppered with a well-pressed, two-holed, cork stopper. In one of the holes is inserted a 50-cc. dropping funnel, which supports an ordinary small funnel. In the other hole is placed a glass tube of 0.5-cm. bore, bent at a right angle, and this is connected with a Liebig condenser.

The dried ether solution of fatty acids is now filtered through a dry, folded filter ($d = 18.5$ cm.) into a 150-cc. Jena Erlenmeyer flask and from there is poured into the dropping funnel. Then about 100 cc. of this solution are run into the 200-cc. flask and the water bath is slowly warmed to about 70° C. As the ether is distilled off, more of the solution is added, drop by drop. The distilled ether is used to extract the Glauber's salt in the separatory funnel, which has absorbed a considerable amount of fatty acids. This is done six times, using from 100 to 120 cc. of ether each time. The fifth extraction is, as a rule, entirely colorless. Finally, by means of an ether wash-bottle, the folded filter, the flask used to receive the filtrate, the small funnel, and the dropping funnel are rinsed off, in order to recover quantitatively the fatty acids adhering to them. After the largest part of the ether is distilled off, the water bath is brought to boiling, and a few more cubic centimeters of ether will then be distilled off.

The extraction of the Glauber's salt and the distilling off of the ether take about $1\frac{1}{2}$ hours. Even after ether has ceased to distill over, the fatty acids still contain some of it. Next, the flame of the water bath is extinguished, the Liebig condenser and dropping funnel are removed, and a tight-fitting stopper, with gas inlet and outlet tubes, is inserted in the flask. The end of the former tube is placed 1 cm. above the surface of the fatty acids. The outlet tube is drawn out to a capillary to prevent the hydrogen gas, which circulates above the fatty acids, from escaping too quickly, and to force it to mix with the ether vapors before leaving the flask. The hydrogen is first purified by passing it through an alkaline lead salt solution and then through concentrated sulphuric acid. The flask is replaced on the water bath, which is kept boiling vigorously. In order to drive off the ether, two hours are required. From four to five gas bubbles per second should pass through the flask. Experiments made with carbon dioxide instead of hydrogen give the same results, but we prefer to use hydrogen. Next, the fatty acids

are removed from the water bath, and, with a clean cloth, the hot flask is wiped off on the outside and inside around the top of the neck; then, while warm, it is put in a vacuum desiccator. This is evacuated to a high degree and then left standing for at least 4 hours. By this means, the fatty acids, as a rule, become partly solid. They are then weighed very quickly and put in a vacuum as before. After 2 hours, the flask is again weighed as quickly as possible, the weights having previously been put on the balance. Finally, the desiccator with flask is once more evacuated, and left standing over night. The next morning, the weight of the flask is checked.

2. *Preparation of the 10-per-cent Ether Solution of Fatty Acids.*—From the 9 to 10 g. of weighed linseed oil fatty acids, a 10-per-cent ether solution is now made. Forty cubic centimeters of ether, dried over calcium chloride, are added to the fatty acids, and carefully shaken until the latter are dissolved. This solution is poured quantitatively into an accurately graduated 100-cc., glass-stoppered, measuring cylinder, the graduation marks of which run half way around the circumference of the cylinder, whereas those for every 10 cc. run entirely around the cylinder. By means of an ether wash-bottle, the empty flask is washed with 20 cc. of ether, well shaken, and this liquid also is poured into the cylinder. The flask is then rinsed again, and care is taken to wash off whatever ether solution has run down on the outside. Then the cylinder is filled up nearly to the 100-cc. mark and shaken. The glass stopper is raised for a moment, and, after a minute, the cylinder is filled to the mark and thoroughly shaken once more. The lower meniscus is read.

3. *The Brominizing Process.*—By means of a standardized pipette, marked at the top and bottom, 20 cc. of the freshly shaken fatty-acid solution are removed from the graduated cylinder and placed in a 100-cc. Jena Erlenmeyer flask with not too narrow a neck. This 20 cc. should contain from 1.9 to 2.0 g. of fatty acids. A cork stopper, with a groove cut in the side, is placed in the flask, and then the latter is put in a cooling mixture of a temperature not exceeding -10° C. This mixture is prepared in a suitable vessel, such as a water bath, by mixing finely broken ice with the necessary quantity of salt, and thoroughly stirring the mixture with a strong glass rod. In winter, snow can be used. The cooling mixture must be so made that the flask can be easily moved in it. After leaving the ether solution in the cooling mixture for 10 minutes, it will have the desired temperature. In the meantime, 1 cc. of commercial bromine is placed in the brominizing burette. A 10-cc. burette, or even a smaller one, is the most suitable, but the glass cock must be well ground in, and the delivery point must be fine. Before brominizing, the flask containing the fatty-acid solution must be shaken slowly in the cooling mixture. Five-tenths cubic centimeter of bromine—half of the quantity to be used—is added in single drops, and then the other 0.5 cc. of bromine, in double drops, keeping the flask cold throughout the operation by carefully shaking it in the cooling mixture. The detailed method of procedure is as follows: The cock of the burette is slowly opened, permitting a single drop of bromine to run down the side of the flask, thereby preventing loss by spattering. The cock of the burette is then closed, and the flask is shaken in the cooling mixture. After from 12 to 15 drops of bromine have been added in this manner, the hex-

abromide of linolenic acid generally begins to precipitate in the form of a fine crystalline powder, which settles quickly. With every additional drop, the precipitate can be plainly seen to increase. After 0.5 cc. of bromine has been added in single drops, which should take approximately 20 minutes, the other 0.5 cc. is added in double drops in exactly the same manner. This will take 10 minutes, so that the entire brominizing process will consume 30 minutes. After cooling for 2 minutes longer, the flask is again shaken and then allowed to stand stoppered for 2 hours in the cooling mixture. Over the precipitate can be seen a reddish brown fluid, a proof of the excess of bromine in the reaction mixture. Quite frequently, it is observed that some of the precipitate adheres to the sides of the flask, due perhaps to the intense cooling. This, however, cannot be avoided, and does not influence the quantitative recovery of the precipitated hexabromide. The time for brominizing, 30 minutes, must be strictly adhered to and must not be shortened. The added bromine disappears almost immediately, until an excess has been added. During the 2-hours standing, the temperature may rise somewhat, but in order to avoid secondary reactions as far as possible, it should never exceed -5°C . In the meantime, the washing ether is prepared. Five cc. of ether are put in each of 5 test tubes, which are stoppered and set in the cooling mixture. For filtering, a Daniel filtering tube is used, which is provided with an asbestos pad, made as thin and uniform as possible. Two grams of Kahlbaum's asbestos, suspended in 500 cc. of water, will be sufficient for a series of determinations. On top of the asbestos a perforated porcelain plate is placed, the diameter of which must be almost as large as the inside diameter of the filtering tube. The perforated plate has about 20 round openings, 2 mm. in diameter. One liter of distilled water is drawn slowly through the tube, and the latter, with its cover, is then dried for one hour at 110°C ., allowed to cool for an hour in the desiccator, and then weighed. In weighing, the tube is suspended by an aluminum wire. After the bromide precipitate has stood for 2 hours in the cooling mixture, it is filtered. The tared filtering tube is connected with a filtering flask, which, however, during the whole filtering process, is not connected with the pump. After making sure once more that the cooling mixture is at the proper temperature, the operator removes the flask containing the hexabromide and wipes it off with a dry cloth, without disturbing the precipitate. With the assistance of a glass rod, and without disturbing the precipitate, the mother-liquor is now carefully poured upon the filter and allowed to drain through completely. In the meantime, the precipitate is thoroughly shaken with the first 5-cc. portion of washing ether and left to settle in the cooling mixture. The ether becomes reddish brown; the precipitate becomes lighter. Immediately after the mother-liquor has run through the filter, the washing liquid in the flask is poured upon the filter, care being taken, however, to retain all the precipitate in the flask. The filter must never become dry, as this would cause a considerable delay in filtering.

The precipitate is then thoroughly mixed with the second 5-cc. portion of ether and brought, as completely as possible, upon the filter, immediately

after the first portion of washing ether has drained through. The precipitate settles immediately, and above it is a yellow solution which filters easily.

The flask is then cleaned with a feather, using the third 5-cc. portion of ether. Next, the precipitate still remaining in the flask is stirred up and brought upon the filter immediately after the preceding washing liquid has drained through. Then, the precipitate on the filter is stirred with a glass rod and is thus freed as much as possible from the mother-liquor. At this point, the washing ether, filtering through, still has a yellowish color, but the precipitate is almost white. The flask is again cleansed with the feather, using the fourth portion of ether. The latter, which is then colorless and contains only a trace of precipitate, is also poured upon the filter, in such a way as to rinse the rim of the filtering tube, up to which some of the mother-liquor has crawled during filtration. The precipitate on the filter is once more stirred up with the glass rod. The ether filtering through is now, in most cases, very faintly yellowish or colorless. Then the last 5-cc. portion of ether is used to rinse the flask once more. The glass rod is now cleaned with the feather, and the entire contents of the flask are brought upon the filter and allowed to run through. Then, with the filtering tube half covered, the filtering flask is connected with the suction pump, and the latter is worked strongly for one minute. The hexabromide shrinks to a very nice white mass. Occasionally, cracks occur in the precipitate. A small quantity of a slightly yellowish fluid is drawn from the bromide by the suction process, and the lower part of the filtering tube often becomes somewhat clouded with a small amount of residue left after the washing ether has evaporated. The filtering tube is now removed from the filtering flask, wiped off outside, and heated in a drying oven for 2 hours at from 80 to 85° C. Then it is allowed to cool for 1 hour in the desiccator and is weighed. It has often been observed that a hexabromide, which would be snow white in color, if dried at 80° C., becomes gray on the surface, if dried at 100° C. During filtration, especially during the first half of it, the precipitate must never become dry. Should this happen before the hexabromide is thoroughly pure, it can hardly be washed out completely, as sticky substances, bromides of various compositions, which, once dried, are difficult to dissolve in ether, adhere to the original precipitate. Before drying, the precipitate must be white, inside and out. If it shows a yellow color anywhere, it will partially melt during the drying process and become gray on the surface. The weight will then be somewhat too high. The filtering, as a rule, takes from 10 to 15 minutes and should not, at all events, exceed 25 minutes. The condition of the asbestos greatly influences the period of filtration. The hexabromide number is obtained by calculating the weight of hexabromide per 100 g. of fatty acids.

The hexabromide method is now so accurate that the hexabromide numbers of the fatty acids obtained by two separate saponifications of the same linseed oil check within 1 per cent. For two determinations run on the same fatty acid solution, the maximum difference is not more than 0.6 per cent. This accuracy is sufficient, as this is a complicated method involving many operations. All determinations by this method with various linseed oils have given very satisfactory results. For instance, with two different

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saponifications of the same oil, the maximum difference was only 0.7 per cent. For the purpose of control, we had the hexabromide number of a linseed oil determined by disinterested parties. An average of 54.10 per cent was found. Two weeks later, we had the hexabromide number of the same linseed oil determined again, and this time the result was 54.21. Two determinations on the same linseed oil gave, as an average, a hexabromide number of 53.66.

It is important, for technical work, to obtain analytical results as quickly as possible. Consequently, we tried to make the hexabromide method more rapid without sacrificing its accuracy.

We saponified the linseed oil in the morning in the usual manner, prepared the ether solution of fatty acids, and let it stand over the Glauber's salt until three in the afternoon (4 to 5 hours). Then the fatty acids were freed from ether and treated with hydrogen for 2 hours. The pure fatty acids were left over night in a highly evacuated desiccator. By quickly weighing in the morning, the weight of acids was ascertained, and then we began the determination of the hexabromide number, so that the result was obtained during the afternoon. In the meantime, the iodine number and saponification number could have been determined, and also a qualitative test could have been made. So a pure linseed oil could be analyzed within two days, excepting in cases where the oil is to be tested for rape seed oil, in which case the separation and identification of erucic acid become necessary. Saponification could also be started in the afternoon, giving the ether solution of fatty acids a chance to stand over night with anhydrous Glauber's salt. The next day, the free fatty acids could be left in the desiccator until afternoon, but at least four hours should be allowed.

Respectfully submitted on behalf of the sub-committee,

GLENN H. PICKARD,
Chairman.

[NOTE.—The proposed Standard Specifications for the Purity of Raw Linseed Oil from North American Seed as amended (see pp. 18-19) were adopted by letter ballot of the Society on August 25, 1913, and follow the report of this sub-committee.—ED.]

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

STANDARD SPECIFICATIONS

FOR

THE PURITY OF RAW LINSEED OIL FROM NORTH AMERICAN SEED.

ADOPTED AUGUST 25, 1913.

I. PROPERTIES AND TESTS.

1. Raw linseed oil from North American seed shall conform to the following requirements: Properties.

	MAXIMUM.	MINIMUM.
Specific Gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.	0.936	0.932
or		
Specific Gravity at $\frac{25^{\circ}}{25^{\circ}}$ C.	0.931	0.927
Acid Number.....	6.00	....
Saponification Number.....	195	189
Unsaponifiable matter, per cent.....	1.50	....
Refractive Index at 25° C.....	1.4805	1.4790
Iodine Number (Hanus).....	....	178

METHODS OF TESTING.

2. The recommended methods of testing are as follows: Methods of Testing.
General.—All tests are to be made on oil which has been filtered at a temperature of between 60° and 80° F. through

paper in the laboratory immediately before weighing out. The sample should be thoroughly agitated before the removal of a portion for filtration or analysis.

Specific Gravity.—Use a pyknometer, accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making a test at 15°.5 C., water being 1 at 15°.5 C., or a test at 25° C., water being 1 at 25° C.

Acid Number.—Expressed in milligrams of KOH per gram of oil. Follow the method described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 142.

Saponification Number.—Expressed as with Acid Number. Blanks should also be run to cover effect of alkali in glass. Follow method given in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, pages 137–138.

Unsaponifiable Matter.—Follow Boemer's method taken from his Ubbelohde Handbuch Der Ole u. Fette, pages 261–262. "To 100 g. of oil in a 1000 to 1500-cc. Erlenmeyer flask add 60 cc. of an aqueous solution of potassium hydroxide (200 g. KOH dissolved in water and made up to 300 cc.) and 140 cc. of 95-per cent alcohol. Connect with a reflux condenser and heat on the water bath, shaking at first until the liquid becomes clear. Then heat for one hour with occasional shaking. Transfer while yet warm to a 2000-cc. separatory funnel to which some water has been added, wash out the Erlenmeyer with water using in all 600 cc. Cool, add 800 cc. of ether and shake vigorously one minute. In a few minutes the ether solution separates perfectly clear. Draw off the soap and filter the ether (to remove last traces of soap) into a large Erlenmeyer and distill off the ether, adding if necessary one or two pieces of pumice stone. Shake the soap solution three times with 400 cc. of ether, which add to the first ether extract. To the residue left after distilling the ether add 3 cc. of the above KOH solution, and 7 cc. of the 95-per cent alcohol, and heat under reflux condenser for 10 minutes on the water bath. Transfer to a small separatory funnel, using 20 to 30 cc. of water, and after cooling shake out with two portions of 100 cc. of ether; wash the ether three times with 10 cc. of water. After drawing off the last of the water, filter the ethereal solution so as to remove the last drops of water, distill off the ether, dry residue in water oven and weigh."

SPECIFICATIONS FOR THE PURITY OF RAW LINSEED OIL. 401

Refractive Index.—Use a properly standardized Abbé Refractometer at 25° C., or any other equally accurate instrument.

Iodine Number (Hanus).—Follow the Hanus method as described in Bulletin No. 107, revised 1908, Department of Agriculture, Bureau of Chemistry, page 136.

REPORT OF SUB-COMMITTEE F ON THE
DEFINITION OF TERMS USED IN PAINT SPECIFICATIONS.

In its last report¹ this sub-committee submitted definitions of certain general terms frequently used in paint specifications. The sub-committee has added to that list proposed definitions of the following terms: covering power, hiding power, spreading power, fineness, hue, tone, drier, density, and gallon.

The sub-committee recommends that these definitions be adopted as standard by the Society. Very often these terms have been used in confusing and contradictory senses. It is hoped that by having standard definitions, paint specifications can be made clearer and less open to differences of opinion as to their meaning.

Respectfully submitted on behalf of the sub-committee,

G. W. THOMPSON,
Chairman.

[NOTE.—According to the regulations governing the adoption of proposed standard definitions, the definitions proposed in this report are printed in the Proceedings, subject to action at the next annual meeting.—ED.]

¹ *Proceedings, Am. Soc. Test. Mats., Vol. XI, p. 223 (1911).*

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

PROPOSED STANDARD DEFINITIONS OF TERMS USED IN PAINT SPECIFICATIONS.

Standard.—A term designating a quality or qualities specified.

Equal to.—The use of this term should be avoided if possible.

Pure.—Standard, without adulteration.

Commercially pure.—Is not defined and should not be used in specifications, as it involves the absence of “*standard*.”

Adulteration.—The partial substitution of one substance for another.

Adulterant.—A substance partially substituted for another.

Bulk.—The bulk of a pigment shall be considered as the total volume of the pigment and the voids, and varies inversely as the specific gravity of that volume.

Voids.—The space between the particles of a pigment, even though occupied by air or by a vehicle, whether liquid or dried.

Opacity.—The obstruction to the direct transmission of visible light afforded by any substance, comparison being made with sections of equal thickness. The opacity in the case of pigments should be considered as referable to their opacity in a vehicle under standard conditions.

Covering power.—The use of this expression should be avoided as being confusing.

Hiding power.—The power of a paint or paint material, as used, to obscure optically a surface painted with it.

Spreading power.—The relative capacity of a paint or paint material, as used, of being brushed out to a continuous uniform paint film expressed in terms of the area to which a unit volume, as used, is applied.

Fineness.—A term used to denote the extent of sub-division and expressive of the number of particles of pigment in a unit volume exclusive of voids.

Crystalline.—Having a definite structure referable to one of the systems of crystallography.

Amorphous.—The opposite of crystalline.

Paint.—A mixture of pigment with vehicle, intended to be spread in thin coats for decoration or protection, or both.

Pigment.—The fine solid particles used in the preparation of paint, and substantially insoluble in the vehicle.

Vehicle.—The liquid portion of a paint.

Volatile thinner.—All that liquid portion of a paint, except water, which is volatile in a current of steam at atmospheric pressure.

Non-volatile vehicle.—The liquid portion of a paint, excepting water, which is not a volatile thinner by the above definition.

Tinting strength.—The relative power of coloring a given quantity of paint or pigment selected as standard for comparison.

Color.—A generic term including the colors of the spectrum, white and black, and all tints, shades and hues which may be produced by their admixture.

Tint.—A color produced by the admixture of a commercial coloring material, excepting white, with a white pigment or paint, the white predominating.

Hue.—The predominating spectral color in a color mixture.

Tone.—The color which principally modifies a hue or a white or a black.

Drying.—The solidification of a liquid film, independent of change in temperature.

Drier.—A material containing metallic compounds added to paints for the purpose of accelerating drying.

Specific gravity.—The relative weight of a unit volume of a substance compared with the weight of the unit volume of water at defined temperatures.

Density.—This is a purely scientific term. Its use should be avoided in specifications.

Gallon.—The measured gallon is 231 cubic inches. Where a measured gallon is called for, the temperature at which it is to be measured should be specified. Where a weighed gallon is called for, the weight should be specified or obtained from the specific gravity of the material at a definite temperature.

Water.—Dissolved water or water not definitely or chemically combined.

Dry.—Containing no uncombined water.

REPORT OF SUB-COMMITTEE J ON THE TESTING
OF WHITE PAINTS.

Sub-Committee J, on the Testing of White Paints, begs to submit the following report. The Proceedings of the Fourteenth Annual Meeting of the Society¹ contain the last published report of the sub-committee. The work planned in that report has been practically completed.

The pigments used were donated by the following manufacturers:

Acme White Lead & Color Co., Samuel H. French & Co., International Pulp Co., Mineral Point Zinc Co., National Lead Co., Neilsen, Klein & Krousse, New Jersey Zinc Co., The Patton Paint Co., Picher Lead Co., Westmoreland Chemical & Color Co., and C. K. Williams & Co.

The oil used in grinding the paints was donated by the American Linseed Co. and National Lead Co.

The drier and the oil used in thinning were donated by the National Lead Co.

The gasoline with which to clean the mills used in the grinding of the paints was donated by The Standard Oil Co.

The turpentine used in thinning the paints for first coats was donated by The Baltimore & Ohio Railroad Co.

The cans used were donated by The American Can Co.

The panels, which were strips of yellow poplar (*Liriodendron tulipifera*, L.) 8 by 1 by 36 in., were donated by The Pennsylvania Railroad Co.

The labor of applying the paint was donated by The Baltimore & Ohio Railroad Co.

The expense of constructing the frame and mounting the test pieces was shared equally by the Bureau of Chemistry of the Department of Agriculture, and the Bureau of Standards of the Department of Commerce and Labor.

¹ Vol. XI, p. 225 (1911).

The specific gravities of the pigments used in calculating the formulas are as follows:

Samples Nos. 1 to 3.—Basic lead carbonate.....	6.6
Samples Nos. 4 to 5.—Zinc oxide.....	5.4
Sample No. 6.—Basic lead sulphate.....	6.3
Sample No. 7.—Leaded zinc oxide.....	5.61
Sample No. 8.—Silica.....	2.64
Sample No. 9.—Asbestine.....	2.78
Sample No. 10.—China clay.....	2.62
Sample No. 11.—Calcium carbonate.....	2.65
Sample No. 12.—Calcium sulphate.....	2.29
Sample No. 13.—Barytes.....	4.23

The specific gravities of the pigments actually used were determined in the laboratory of the National Lead Company by the following method:

Apparatus.—The apparatus used in this method consists of a burette, similar in shape to a thistle-tube, 38 in. high, having a capacity of 100 cc. with only 20 cc. graduated, each cubic centimeter having 50 divisions; the 20-cc. graduation has a length of $28\frac{1}{2}$ in., and the burette is 8 mm. in diameter in this length. Also, a 100-cc. graduated glass-stoppered flask with narrow neck, a short-stem 2-in. funnel, and a stiff piece of brass wire.

Finding the Capacity of Flask.—Fill the specific gravity burette with kerosene oil that has been filtered and find the capacity of the 100-cc. graduated glass-stoppered flask, letting the burette drain for 15 minutes before taking the reading. The precaution of letting the burette drain for 15 minutes before taking the reading should be followed in each determination. Note the temperature of the room and regulate the ventilation, having the temperature remain near this point while making all determinations.

Method.—Weigh out 100 g. of finely divided (crushed) sample of pigment, if the pigment is a fairly heavy one; if the pigment is a light one, weigh out 25 g. Place the weighed portion in the 100-cc. flask by running through the short-stem funnel, using the wire if necessary to aid in getting the pigment through the stem of the funnel. If desirable, the dry flask may be weighed before and after the addition of the pigment in the flask. Fill the specific gravity burette with kerosene oil; allow the oil to run into the flask containing the pigment until it is level with the 100-cc. mark on the flask, and put in the glass stopper. Place the neck of the flask between the palms of the hands and move one hand back and forth, giving the flask a rotating motion and wetting the pigment thoroughly with kerosene. To displace the last trace of air bubbles, tap the flask gently on a cloth-covered surface. Remove the glass stopper carefully, letting any kerosene that may have collected on the stopper run back into the flask. Make the volume in the flask up to the 100-cc. mark, adding more kerosene from the burette. This

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operation should be repeated until the rotating motion and tapping do not change the volume of the kerosene in the flask, denoting that all of the air has been displaced. When the volume in the flask is constant, let the burette drain for the required time and then take the reading.

Letting A = Capacity of flask;

B = Reading of burette;

C = Volume of pigment in flask ($A - B = C$);

D = Weight in grams of the pigment used in determination; and

E = Specific gravity of the pigment;

the specific gravity of the pigment is $E = \frac{D}{A - B (= C)}$

Notes.—The most convenient temperature to work with will be room temperature, about 21° C., having the kerosene oil and apparatus in the room for some time before starting determinations.

To remove the kerosene from the flask after each determination, rinse the flask twice with ether and dry with air from blastlamp bellows.

The specific gravities obtained are as follows:

Sample No. 1.—Basic Lead Carbonate, designated by the manufacturer as Dutch Process White Lead.....	6.38
Sample No. 2.—Basic Lead Carbonate, designated by the manufacturer as Carter White Lead.....	6.72
Sample No. 3.—Basic Lead Carbonate, designated by the manufacturer as Mild Process White Lead.....	6.67
Sample No. 4.—Zinc Oxide, designated by the manufacturer as Florence Green Seal French Process Zinc Oxide.....	5.55
Sample No. 5.—Zinc Oxide, designated by the manufacturer as XX American Process Zinc Oxide.....	5.45
Sample No. 6.—Basic Lead Sulphate, designated by the manufacturer as Sublimed White Lead.....	6.33
Sample No. 7.—Leaded Zinc Oxide, designated by the manufacturer as Leaded Oxide of Zinc.....	5.68
Sample No. 8.—Siliceous Material, designated by the manufacturer as Silica.....	2.66
Sample No. 9.—Silicate, designated by the manufacturer as Asbestine.	2.77
Sample No. 10.—Clay, designated by the manufacturer as L.G.V. China Clay.....	2.60
Sample No. 11.—Calcium Carbonate, designated by the manufacturer as Extra Gilders Whiting, Bolted.....	2.68
Sample No. 12.—Calcium Sulphate, designated by the manufacturer as such.....	2.30
Sample No. 13.—Barium Sulphate, designated by the manufacturer as Cream Floated Lead Bloom (Water-Floated Barytes).	4.43

ANALYSES OF PIGMENTS.

The pigments were sampled by Messrs. Sabin and Rogers and samples were sent to a number of members of the committee who intended to make analyses. Up to the present time only two sets of analyses have been received, from the Bureau of Standards and the Bureau of Chemistry. As these analyses were made entirely independently, and differ in mode of expression, it is deemed best to report the results of each analyst independently of the other.

Following are the analyses reported from the Bureau of Standards:

SAMPLE NO. 1.—BASIC LEAD CARBONATE (DUTCH PROCESS WHITE LEAD).

(Lab. No. 1121, Test No. Ic-9).

	Per cent.
Carbonic anhydride (CO_2)	<div> <div>by evolution and absorption in soda lime:</div> <div>11.69, 11.73 (Av. 11.7%).</div> <div>by combustion and absorption in soda lime: 11.8, 11.9, 11.8, 11.9.....</div> </div>
Total H_2O —by combustion and absorption in CaCl_2 :	2.32, 2.31, 2.27. 2.30
Residue after ignition: 85.83, 85.81, 85.83, 85.86, 85.83.....	85.86
Lead oxide (PbO)—weighed as PbSO_4 :	84.9, 85.0 .. 85.0
Moisture—by drying at 95°C	0.26
Insoluble siliceous matter.....	0.03

Probable Composition.

Lead carbonate (PbCO_3)—calculated from CO_2 by evolution (11.7%)	71.0
Lead hydrate ($\text{Pb}(\text{OH})_2$)—calculated from total H_2O corrected for moisture (2.04%).....	27.3
Moisture.....	0.26
Insoluble siliceous matter.....	0.03
Color—white, slightly brown.	

SAMPLE NO. 2.—BASIC LEAD CARBONATE (CARTER WHITE LEAD).

(Lab. No. 1122, Test No. Ic-9.)

	Per cent.
Carbonic anhydride (CO_2),	<div> <div>by evolution and absorption in soda lime:</div> <div>11.60, 11.57 (Av. 11.6%).</div> <div>by combustion and absorption in soda lime: 11.7, 11.7, 11.7.....</div> </div>
Total H_2O —by combustion and absorption in CaCl_2 :	2.35, 2.33, 2.312 2.34
Residue after ignition: 86.15, 86.15, 86.18.....	86.16

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SAMPLE No. 2.— <i>Continued.</i>		Per cent.
Lead oxide (PbO)—weighed as PbSO ₄ : 85.8, 85.9.....		85.9
Moisture—by drying at 95° C.....		0.10
Insoluble siliceous matter		0.02

Probable Composition.

Lead Carbonate (PbCO ₃)—calculated from CO ₂ by evolution (11.6%).....	70.3
Lead hydrate (Pb(OH) ₂)—calculated from total H ₂ O corrected for moisture (2.24%).....	30.0
Moisture.....	0.10
Insoluble siliceous matter.....	0.02

Color—practically white.

SAMPLE No. 3.—BASIC LEAD CARBONATE (MILD PROCESS WHITE LEAD). (Lab. No. 1123, Test No. Ic-9.)

	Per cent.
Carbonic anhydride (CO ₂), { by evolution and absorption in soda lime: 11.57, 11.56 (Av. 11.6%).	
{ by combustion and absorption in soda lime: 11.7, 11.7, 11.7.....	11.7
Total H ₂ O—by combustion and absorption in CaCl ₂ : 2.17, 2.14, 2.17	2.16
Residue after ignition: 86.30, 86.28, 86.30.....	86.29
Lead oxide (PbO)—weighed as PbSO ₄ : 85.6, 85.7....	85.7
Moisture—by drying at 95° C.....	0.08
Insoluble siliceous matter.....	0.05

Probable Composition.

Lead carbonate (PbCO ₃)—calculated from CO ₂ by evolution (11.57%)	70.2
Lead hydrate (Pb(OH) ₂)—calculated from total H ₂ O corrected for moisture (2.08%).....	27.9
Moisture.....	0.08
Insoluble siliceous matter	0.05

Color—white, with brownish tint.

SAMPLE No. 4.—ZINC OXIDE (FLORENCE GREEN SEAL FRENCH PROCESS ZINC OXIDE).

(Lab. No. 1124, Test No. Ic-9.)

	Per cent.
Zinc oxide (ZnO)—titrated with K ₄ Fe(CN) ₆	99.36
Lead oxide (PbO)—determined as sulphate.....	0.25
Oxides of iron and aluminum (Fe ₂ O ₃ +Al ₂ O ₃).....	0.07
Sulphuric anhydride (SO ₃).....	0.16
Moisture—by drying at 105° C.....	0.10

Color—white.

SAMPLE No. 5.—ZINC OXIDE (XX AMERICAN PROCESS ZINC OXIDE).

(Lab. No. 1125, Test No. Ic-9.)

	Per cent
Zinc oxide (ZnO)—titrated with $K_4Fe(CN)_6$	98.88
Lead oxide (PbO)—determined as sulphate.....	0.21
Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).....	0.22
Sulphuric anhydride (SO_3).....	0.38
Moisture—by drying at 105° C.....	0.24
Color—white, with a yellowish brown tint.	

SAMPLE No. 6.—BASIC LEAD SULPHATE (SUBLIMED WHITE LEAD).

(Lab. No. 1126, Test No. Ic-9.)

	Per cent
Lead oxide (PbO)—determined as sulphate.....	72.20
Zinc oxide (ZnO)—titrated with $K_4Fe(CN)_6$	6.16
Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).....	0.08
Sulphuric anhydride (SO_3).....	21.19
Moisture—by drying at 105° C.....	0.10
Loss by ignition after drying.....	0.19

Probable Composition.

Lead sulphate ($PbSO_4$).....	80.22
Lead oxide (PbO).....	13.17
Zinc oxide (ZnO).....	6.16
Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).....	0.08
Moisture, organic matter, etc.....	0.29
Color—white, with a yellowish brown tint.	

SAMPLE No. 7.—LEADED ZINC OXIDE (LEADED OXIDE OF ZINC).

(Lab. No. 1127, Test No. Ic-9.)

	Per cent
Lead oxide (PbO)—determined as sulphate.....	11.37
Zinc oxide (ZnO)—titrated with $K_4Fe(CN)_6$	84.90
Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).....	0.10
Sulphuric anhydride (SO_3).....	3.54
Moisture—by drying at 105° C.....	0.18

Probable Composition.

Lead sulphate ($PbSO_4$).....	13.40
Lead oxide (PbO).....	1.51
Zinc oxide (ZnO).....	84.90
Oxides of iron and aluminum ($Fe_2O_3 + Al_2O_3$).....	0.10
Moisture.....	0.18
Color—white, with a shade of yellowish brown.	

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SAMPLE No. 8.—SILICEOUS MATERIAL (SILICA).

(Lab. No. 1128, Test No. Ic-9.)

	Per cent.
Soluble in HCl (1:5)	16.49
Insoluble in HCl (1:5)	80.17
Loss on ignition.....	4.85

Soluble Portion.

Lime (CaO)—oxalate titrated with KMnO_4	3.75
Magnesia (MgO)—weighed as pyrophosphate.....	6.63
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.57
Silica (SiO_2).....	1.78
Carbonic anhydride (CO_2)—by evolution and absorption in soda lime	3.59
Moisture—by drying at 105°C	0.17

Insoluble Portion.—The insoluble portion was fused with Na_2CO_3 , and the following analysis obtained:

Lime (CaO)—oxalate titrated with KMnO_4	1.76
Magnesia (MgO)—as pyrophosphate.....	8.81
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.47
Silica (SiO_2).....	68.12

Color—white, tinted with gray.

SAMPLE No. 9.—SILICATE (ASBESTINE).

(Lab. No. 1129, Test No. Ic-9.)

	Per cent.
Soluble in HCl (1:5)	7.67
Insoluble in HCl (1:5)	89.57
Loss on ignition.....	2.25

Soluble Portion.

Lime (CaO)—oxalate titrated with KMnO_4	0.39
Magnesia (MgO)—as pyrophosphate.....	5.26
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.14
Silica (SiO_2).....	1.63
Moisture—by drying at 105°C	0.25

Insoluble Portion.—The insoluble portion was fused with Na_2CO_3 , and the following analysis obtained:

Lime (CaO)—oxalate titrated with KMnO_4	5.19
Magnesia (MgO)—as pyrophosphate.....	23.35
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.35
Silica (SiO_2).....	58.95

Color—white, with a very light tint of brown.

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SAMPLE No. 10.—CLAY (L. G. V. CHINA CLAY).

(Lab. No. 1130, Test No. Ic-9.)

	Per cent.
Loss on ignition.....	12.65
Oxide of aluminum (Al_2O_3).....	38.75
Magnesia (MgO)—as pyrophosphate.....	0.25
Silica (SiO_2).....	46.59
Color—white, with a brownish tinge.	

SAMPLE No. 11.—CALCIUM CARBONATE (EXTRA GILDERS WHITING, BOLTED).

(Lab. No. 1131, Test No. Ic-9.)

	Per cent.
Lime (CaO)—weighed as CaO from the oxalate.....	54.82
Magnesia (MgO)—as pyrophosphate.....	0.29
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.25
Carbonic anhydride (CO_2)—by evolution and absorption in soda lime	42.98
Insoluble.....	1.15
Moisture—by drying at 105°C	0.13

Probable Composition.

Calcium carbonate (CaCO_3).....	97.86
Magnesium carbonate (MgCO_3).....	0.60
Oxides of iron and aluminum ($\text{Fe}_2\text{O}_3 + \text{Al}_2\text{O}_3$).....	0.25
Clay.....	1.15
Moisture.....	0.13
Color—white, slightly tinted yellowish brown.	

SAMPLE No. 12.—CALCIUM SULPHATE.

(Lab. No. 1132, Test No. Ic-9.)

	Per cent.
Lime (CaO)—weighed as CaO from the oxalate.....	32.84
Magnesia (MgO)—as pyrophosphate.....	0.10
Sulphuric anhydride (SO_3).....	45.55
Carbonic anhydride (CO_2)—by evolution and absorption in soda lime	0.70
Insoluble.....	0.40
Loss at dull red heat (moisture, combined water, etc.).....	20.54

Probable Composition.

Calcium sulphate (CaSO_4).....	77.2
Magnesium sulphate (MgSO_4).....	0.3
Calcium carbonate (CaCO_3).....	1.6
Clay.....	0.4
Water, etc.....	20.5

Color—white, with a gray tint.

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SAMPLE NO. 13.—BARIUM SULPHATE (CREAM FLOATED LEAD BLOOM— WATER-FLOATED BARYTES).

(Lab. No. 1132, Test No. Ic-9.)

The material was boiled with HCl (1:5).

<i>Soluble Portion.</i>	Per cent.
Silica (SiO ₂).....	0.25
Oxides of iron and aluminum (Fe ₂ O ₃ +Al ₂ O ₃).....	1.65
Magnesia (MgO).....	0.11
Sulphuric anhydride (SO ₃).....	0.34
Loss on ignition.....	0.30

Insoluble Portion.—98.30 per cent, after fusion with Na₂CO₃,
showed no other ingredients present except Barium Sulphate (BaSO₄).

Color—white.

It was the original intention of the Bureau of Standards to make a very complete analysis of each of the pigments included in these tests, and also to state in detail the methods of analysis employed. This, however, was found impossible. As the methods used were not novel and in most cases the method of determination is indicated, a further discussion is not considered necessary.

Following are the results of analyses made at the Bureau of Chemistry:

SAMPLE NO. 1.—BASIC LEAD CARBONATE (DUTCH PROCESS WHITE LEAD). (Contract No. 11520.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer).....	6.46
Moisture (H ₂ O)—vacuum desiccator method.....	0.63
2 hr. in air bath at 105° C.....	0.69
76 " " " " " 105° C.....	0.87
17 hr. in water-jacketed oven at 99° C.....	0.71
CaC ₂ method.....	0.61
Total loss on ignition.....	14.4
Total lead as PbO—PbSO ₄ method.....	85.0
PbCrO ₄ gravimetric method (Fresenius).....	85.2
PbCrO ₄ gravimetric method (McDonnell).....	85.1
Ignition and correction for non-volatile other than PbO.....	85.2

SAMPLE NO. 1.—*Continued.*

	Per cent.
Carbonic anhydride (CO_2)—evolution with acid and weighing as BaCO_3	11.7 (=71.0% PbCO_3).
Evolution with acid and weighing in KOH bulb....	11.6
Direct ignition, weighing in soda lime.....	11.7
Combined water (H_2O)—direct ignition and weighing in CaCl_2 tube corrected for moisture	2.02 (=27.1% Pb(OH)_2).
Calculated from total loss on ignition, moisture and CO_2	2.07
Acetates as CH_3COOH —Thompson's method...	0.12
Insoluble siliceous matter (SiO_2 , etc.).....	0.03
Lead oxide (PbO)—insoluble in CH_3COOH and soluble in $\text{CH}_3\text{COONH}_4$	0.25 (=0.34% PbSO_4)
Lead oxide (PbO)—insoluble in CH_3COOH and $\text{CH}_3\text{COONH}_4$, but soluble in HNO_3	0.00 (=0.00% PbSO_4).
Sulphuric anhydride (SO_3).....	0.08 (=0.31% PbSO_4).
Sulphurous anhydride (SO_2).....	0.00 (=0.00% PbSO_4).
Bismuth as Bi_2O_3 —32-g. sample taken; weighed as BiOCl	0.02
Iron as Fe_2O_3 —10 to 32-g. sample taken; final weighing as Fe_2O_3	0.01
Lime (CaO)—10 to 32-g. sample taken; final weighing as CaO	0.05
Magnesia (MgO)—10 to 32-g. sample taken; final weighing as MgO (ammonium carbonate method).....	0.04
Alkalies as Na_2O —10-g. sample taken; final weighing as Na_2SO_4	0.19

SAMPLE NO. 2.—BASIC LEAD CARBONATE (CARTER WHITE LEAD).
(Contract No. 11521.)

	Per cent.
Specific gravity at $\frac{15^\circ.5}{15^\circ.5}$ C. (pycnometer),	6.85
Moisture (H_2O)—vacuum desiccator method....	0.09
2 hr. in air bath at 105° C.....	0.12
CaC_2 method.....	0.09
Total loss on ignition.....	13.8
Total lead as PbO — PbSO_4 method.....	86.2
PbCrO_4 gravimetric method (Fresenius)	86.4
PbCrO_4 gravimetric method (McDonnell).....	86.2
Ignition and correction for non-volatile other than PbO	86.1

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SAMPLE No. 2.—*Continued.*

	Per cent.
Carbonic anhydride (CO ₂)—evolution with acid and weighing as BaCO ₃	11.6 (=70.4% PbCO ₃).
Evolution with acid and weighing in KOH bulb.....	11.6
Direct ignition, weighing in soda lime.....	11.7
Combined water (H ₂ O)—direct ignition and weighing in CaCl ₂ tube corrected for moisture	2.20 (=29.5% Pb(OH) ₂)
Calculated from total loss on ignition, moisture and CO ₂	2.10
Acetates as CH ₃ COOH—Thompson's method...	0.15
Insoluble siliceous matter (SiO ₂ , etc.).....	0.01
Lead oxide (PbO)—insoluble in CH ₃ COOH and soluble in CH ₃ COONH ₄	0.23 (=0.31% PbSO ₄).
Lead oxide (PbO)—insoluble in CH ₃ COOH and CH ₃ COONH ₄ , but soluble in HNO ₃	0.00 (=0.00% PbSO ₄).
Sulphuric anhydride (SO ₃).....	0.08 (=0.31% PbSO ₄).
Sulphurous anhydride (SO ₂).....	0.02 (=0.09% PbSO ₄).
Bismuth as Bi ₂ O ₃ —32-g. sample taken; weighed as BiOCl.....	0.03
Iron as Fe ₂ O ₃ —10 to 32-g. sample taken; final weighing as Fe ₂ O ₃	0.01
Lime (CaO)—10 to 32-g. sample taken; final weighing as CaO.....	0.01
Magnesia (MgO)—10 to 32-g. sample taken; final weighing as MgO (ammonium carbonate method).....	0.01
Alkalies as Na ₂ O—10-g. sample taken; final weighing as Na ₂ SO ₄	0.05

SAMPLE No. 3.—BASIC LEAD CARBONATE (MILD PROCESS WHITE LEAD.) (Contract No. 11522.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pyknometer),	6.85
Moisture (H ₂ O)—vacuum desiccator method....	0.04
2 hr. in air bath at 105° C.....	0.19
CaC ₂ method.....	0.19
Total loss on ignition.....	13.8
Total lead as PbO—PbSO ₄ method.....	86.1
PbCrO ₄ gravimetric method (Fresenius).....	86.4
PbCrO ₄ gravimetric method (McDonnell).....	86.5

SAMPLE NO. 3.—*Continued.*

	Per cent.
Ignition and correction for non-volatile other than PbO.....	86.2
Carbonic anhydride (CO ₂)—evolution with acid and weighing as BaCO ₃	11.6 (=70.4% PbCO ₃).
Evolution with acid and weighing in KOH bulb.....	11.6
Direct ignition, weighing in soda lime.....	11.7
Combined water (H ₂ O)—direct ignition and weighing in CaCl ₂ tube corrected for moisture	2.17 (=29.1% Pb(OH) ₂)
Calculated from total loss on ignition, moisture and CO ₂	2.09
Acetates as CH ₃ COOH—Thompson's method...	0.00
Insoluble siliceous matter (SiO ₂ , etc.).....	0.06
Lead oxide (PbO)—insoluble in CH ₃ COOH and soluble in CH ₃ COONH ₄	0.67 (=0.91% PbSO ₄).
Lead oxide (PbO)—insoluble in CH ₃ COOH and CH ₃ COONH ₄ , but soluble in HNO ₃	0.11 (=0.14% PbSO ₄).
Sulphuric anhydride (SO ₃).....	0.23 (=0.87% PbSO ₄).
Sulphurous anhydride (SO ₂).....	0.06 (=0.27% PbSO ₄).
Bismuth as Bi ₂ O ₃ —32-g. sample taken; final weighing as BiOCl.....	trace
Iron as Fe ₂ O ₃ —10 to 32-g. sample taken; final weighing as Fe ₂ O ₃	0.02
Lime (CaO)—10 to 32-g. sample taken; final weighing as CaO.....	0.01
Magnesia (MgO)—10 to 32-g. sample taken; final weighing as MgO (ammonium carbonate method).....	0.01
Alkalies as Na ₂ O—10-g. sample taken; final weighing as Na ₂ SO ₄	0.03

SAMPLE NO. 4.—ZINC OXIDE (FLORENCE GREEN SEAL FRENCH PROCESS ZINC OXIDE).

(Contract No. 11523.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pyknometer)..	5.68
Color—white.	
Moisture (H ₂ O)—vacuum desiccator method....	0.09
2 hr. in air bath at 105° C.....	0.08
CaC ₂ method.....	0.11
Total loss on ignition.....	0.20
Insoluble siliceous matter (SiO ₂ , etc.).....	0.01

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SAMPLE No. 4.—Continued.

	Per cent.
Total zinc as ZnO.....	99.3
Total lead as PbO.....	0.26
Arsenic—calculated as As ₂ O ₃	trace
Antimony.....	not detected
Iron as Fe ₂ O ₃	0.04
Alumina (Al ₂ O ₃).....	0.05
Manganese as MnO.....	not detected
Cadmium as CdO.....	0.08
Calcium.....	not detected
Magnesium.....	not detected
Carbonic anhydride (CO ₂).....	0.08
Chlorine (Cl).....	0.05
Total sulphuric anhydride (SO ₃).....	0.19
Sulphurous anhydride (SO ₂).....	not detected
Water-soluble zinc as ZnO.....	0.06 (= 0.13% ZnSO ₄).
Excess SO ₂ —calculated to PbSO ₄	0.45 (= 0.33% PbO).
Bismuth, copper, silver, and tin.....	not detected
Alkalies.....	not tested for

SAMPLE No. 5.—ZINC OXIDE (XX AMERICAN PROCESS ZINC OXIDE). (Contract No. 11524.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer)...	5.60
Color—yellowish white.	
Moisture (H ₂ O)—vacuum desiccator method....	0.16
2 hr. in air bath at 105° C.....	0.16
CaC ₂ method.....	0.16
Total loss on ignition.....	0.86
Insoluble siliceous matter (SiO ₂ , etc.).....	0.02
Total zinc as ZnO.....	98.4
Total lead as PbO.....	0.37
Arsenic—calculated as As ₂ O ₃	0.16
Antimony.....	trace.
Iron as Fe ₂ O ₃	0.06
Alumina (Al ₂ O ₃).....	0.07
Manganese as MnO.....	0.03
Cadmium as CdO.....	0.07
Calcium.....	not detected
Magnesium.....	not detected
Carbonic anhydride (CO ₂).....	0.05
Chlorine (Cl).....	0.09
Total sulphuric anhydride (SO ₃).....	0.42
Sulphurous anhydride (SO ₂).....	trace

SAMPLE No 5.—*Continued.*

	Per cent.
Water-soluble zinc as ZnO.....	0.47 (= 0.94% ZnSO ₄).
Excess SO ₃ —calculated as PbSO ₄	0.00
Bismuth, copper, silver, and tin.....	not detected
Alkalies.....	not tested for

SAMPLE No. 6.—BASIC LEAD SULPHATE (SUBLIMED WHITE LEAD).
(Contract No. 11525.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) ..	6.43
Moisture (H ₂ O)—vacuum desiccator method....	0.07
CaC ₂ method.....	0.06
Bismuth—1-g. sample taken.....	trace
Total lead as PbO.....	72.4
Total zinc as ZnO.....	5.7
Total sulphuric anhydride (SO ₃).....	22.1
Soluble sulphuric anhydride (SO ₃).....	0.12
Qualitative tests using small portions failed to detect other ingredients.	

Probable Composition (calculated).

Lead sulphate (PbSO ₄).....	83.0
Lead oxide (PbO).....	11.1
Zinc sulphate (ZnSO ₄).....	0.3
Zinc oxide (ZnO).....	5.6

SAMPLE No. 7.—LEADED ZINC OXIDE (LEADED OXIDE OF ZINC).
(Contract No. 11526.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) ..	5.79
Moisture (H ₂ O)—vacuum desiccator method....	0.08
CaC ₂ method.....	0.12
Total lead as PbO.....	11.5
Total zinc as ZnO.....	85.1
Total sulphuric anhydride (SO ₃).....	4.0
Soluble sulphuric anhydride (SO ₃).....	0.23
Qualitative tests using small portions failed to detect other ingredients.	

Probable Composition (calculated).

Lead sulphate (PbSO ₄).....	14.0
Lead oxide (PbO).....	1.1
Zinc sulphate (ZnSO ₄).....	0.5
Zinc oxide (ZnO).....	84.4

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SAMPLE No. 8.—SILICEOUS MATERIAL (SILICA). (Contract No. 11527.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	2.69
Moisture (H ₂ O)—vacuum desiccator method . . .	0.25
CaC ₂ method	0.22
Total loss on ignition	7.22
Silica (SiO ₂)	69.9
Iron oxide and alumina (Fe ₂ O ₃ + Al ₂ O ₃)—uncor- rected	0.92
Lime (CaO)	5.74
Magnesia (MgO)	16.0
Manganese—1 g. of material taken	trace
Qualitative tests using small portions (about 1 g.) failed to detect other ingredients.	

SAMPLE No. 9.—SILICATE (ASBESTINE). (Contract No. 11528.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	2.80
Moisture (H ₂ O)—vacuum desiccator method . . .	0.71
2 hr. in air bath at 105° C.	0.72
CaC ₂ method	0.61
Total loss on ignition	5.09
Silica (SiO ₂)	60.1
Alumina (Al ₂ O ₃)—uncorrected	0.27
Iron as Fe ₂ O ₃	0.22
Manganese as MnO	0.53
Lime (CaO)	5.40
Magnesia (MgO)	28.9

SAMPLE No. 10.—CLAY (L. G. V. CHINA CLAY). (Contract No. 11529.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	2.60
Moisture (H ₂ O)—vacuum desiccator method . . .	0.58
CaC ₂ method	0.53
Total loss on ignition	12.9
Silica (SiO ₂)	46.5
Iron oxide and alumina (Fe ₂ O ₃ + Al ₂ O ₃)—uncor- rected	40.8
Titanium, phosphorus, and unusual elements . .	not tested for

ON THE TESTING OF WHITE PAINTS.

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SAMPLE NO. 11.—CALCIUM CARBONATE (EXTRA GILDERS WHITING, BOLTED).
(Contract No. 11530.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	2.69
Moisture (H ₂ O)—vacuum desiccator method . . .	0.14
2 hr. in air bath at 105° C.	0.15
CaC ₂ method	0.17
Total loss on ignition	43.6
Carbonic anhydride (CO ₂)—evolution with acid and weighing as BaCO ₃	43.5
Evolution with acid and weigh- ing in KOH bulb	43.5
Sulphuric anhydride (SO ₃)	0.26
Total insoluble siliceous matter	1.02
Silica (SiO ₂)	0.59
Alumina (Al ₂ O ₃)	0.16
Iron as Fe ₂ O ₃	0.11
Lime (CaO)	54.7
Magnesia (MgO)	0.31

SAMPLE NO. 12.—CALCIUM SULPHATE.
(Contract No. 11531.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	2.33
Moisture (H ₂ O)—vacuum desiccator method . . .	0.13
Total loss in air bath at 105° C. for 27 hr.	19.7
Total loss in air bath at 200°– 220° C. constant weight, about 10 hr.	20.2
CaC ₂ method:—Some combined H ₂ O given off below 100° C. (The vacuum desiccator method is the only one which gives results at all reliable.)	
Total loss by heating to low redness	20.4
Insoluble siliceous matter	0.40
Iron oxide and alumina (Fe ₂ O ₃ + Al ₂ O ₃)	0.00
Lime (CaO)	32.7
Magnesia (MgO)	0.13
Sulphuric anhydride (SO ₃)	45.6
Carbonic anhydride (CO ₂)	0.67

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SAMPLE NO. 13.—BARIUM SULPHATE (CREAM FLOATED LEAD BLOOM—
WATER-FLOATED BARYTES).
(Contract No. 11532.)

	Per cent.
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C. (pycnometer) . .	4.47
Moisture (H ₂ O)—vacuum desiccator method	0.05
2 hr. in air bath at 105° C.	0.06
CaC ₂ method	0.07
Total loss on ignition	0.27
Silica (SiO ₂)	0.26
Total sulphuric anhydride (SO ₃)	34.3
Alumina (Al ₂ O ₃ , etc.)—uncorrected	1.00
Iron oxide (Fe ₂ O ₃)	0.04
Baryta (BaO)	64.6
Lime (CaO)	0.02
Magnesia (MgO)	0.13

The Bureau of Chemistry intended to make exhaustive analyses of all the samples, but it was found that the necessary time could not be given for this work on all of them. The analyses of the three samples of white lead, however, are complete, and the samples were used to test the accuracy of some of the methods of determination. It is clear from the figures found that moisture determinations in such materials are exceedingly difficult, and the calculations of the amounts of lead carbonate and lead hydrate are therefore subject to very great errors. When we consider that moisture determinations by methods which are generally considered standard may vary by nearly 0.2 per cent, which would correspond to over 2.6 per cent of lead hydrate, and that the CO₂ determinations frequently vary as much as 0.2 per cent, even with the most skillful analyst, it would appear that any attempt to calculate accurately the amount of carbonate and hydrate in a sample of white lead is nearly impossible for routine work.

The specific gravity determinations were all made with a pycnometer, which method is, in the opinion of the sub-committee, unsatisfactory for determining the specific gravity of pigments. A method similar to that used with cements should be employed, but this would have necessitated the use of larger quantities of the pigment than would have been justified from the quantity of the samples submitted.

ANALYSES OF OILS, TURPENTINE AND DRIER.

A chemical analysis of the oil used in grinding the paints, made at the Bureau of Standards, follows:

RAW LINSEED OIL.

(Lab. No. 1404, Test No. Ic-9.)

Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.....	0.9326
Ash, siliceous, per cent.....	0.12
Acid number.....	1.4
Iodine number.....	190.2
Saponification number.....	190.4

A chemical analysis of the oil used in thinning the paints for the first coats, made at the Bureau of Chemistry, follows:

RAW LINSEED OIL.

(Contract No. 15553.)

Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.....	0.9356
Color.....	normal
Odor.....	normal
Taste.....	normal
Turbidity.....	considerable
Foots.....	considerable
Loss ($\frac{1}{2}$ hr. at 105° C.), per cent.....	0.27
Saponification number.....	191.4
Acid number.....	1.9
Iodine number (Hanus) of oil.....	188.4
Iodine number (Hanus) of insoluble fatty acids.....	196.6
Unsaponifiable, per cent.....	1.22
Ash, per cent.....	0.19
Refractive index at 25° C.....	1.4803

A chemical analysis of the turpentine used in thinning the first coats, made in the Bureau of Chemistry, follows:

TURPENTINE.

(L. & P. No. 24552, Contract No. 15552.)

Specific gravity at 20° C.....	0.8644
Color:—more than 200 mm. required to equal in color Lovibond yellow glass No. 1.	
Odor.....	gum spirits
Refractive index at 20° C.....	1.4680

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TURPENTINE.—*Continued.*

Distillation at 760 mm. pressure:

Initial boiling point.....	158° C.
Below 160° C., per cent.....	7.9
Below 165° C., ".....	92.4
Below 170° C., ".....	96.6
Residue, ".....	3.4
Polymerization residue, ".....	0.4
Consistency of residue.....	viscous
Boil-down test (100° C.), per cent.....	0.5
Drop on white paper.....	no residue

A sample of the drier used in making the paints was analyzed at the Bureau of Chemistry and gave the following results:

DRIER FOR WHITE PIGMENT TESTS.

(From Dr. Allen Rogers, Am. Soc. Test. Mats.; Contract No. 15578.)

Appearance.....	dark brown, turbid, very viscous
Odor.....	heated linseed oil
Specific gravity at $\frac{15^{\circ}.5}{15^{\circ}.5}$ C.....	0.985
Water.....	small amount
Volatile oil.....	none
Total lead (Pb), per cent.....	2.51
Total manganese (Mn), per cent.....	1.09
Lime.....	very small amount
Total ash, per cent.....	4.54
Reaction of ash.....	faintly alkaline
Acid number.....	28.0
Rosin.....	not detected

When mixed with 8 parts raw linseed oil, the material shows a turbidity and a deposit on standing.

The mixture dries free from tackiness in 2 hrs.

The mixture dries hard in more than 8 and less than 24 hrs.

Nature of film after 24 hrs.: hard, clear and elastic.

DESCRIPTION OF TESTS.

The paints were prepared by Prof. Allen Rogers of Pratt Institute, Brooklyn, according to the plan outlined in the last report.¹ In order to obtain a standard consistency for the paints used in the test, Professor Rogers, The Patton Paint Co., and the Sherwin-Williams Co., prepared independently a paint which they considered of the proper consistency. Professor

¹*Proceedings, Am. Soc. Test. Mats., Vol. XI, p. 225 (1911).*

PLATE IX.
PROC. AM. SOC. TEST. MATS.
VOL. XIII.
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OF COMMITTEE D-1.

Paint No.	No. 1—Basic Lead Carbonate, lb.	No. 2—Basic Lead Carbonate, lb.	No. 3—Basic Lead Carbonate, lb.	No. 4—Zinc Oxide, lb.	Volume of Pigment, oz. per gal.	Weight of Pigment per Gal., lb.	Weight of Paint per Gal., lb.	Drier, oz. per gal.	Paint No.
101	41.25				34	14.6	20.3	4.75	101
102		41.25			35	15.0	20.6	4.65	102
103			41.25		27	10.8	16.9	5.05	103
104				34.75	16	5.6	12.4	5.60	104
105					17	7.2	13.9	5.50	105
106					26	10.6	16.8	5.10	106
107					25	9.0	15.2	5.15	107
201	33.00			6.75	28	11.5	17.5	5.00	201
202	33.00				31	13.1	18.9	4.85	202
203	33.00				33	12.4	18.1	4.75	203
204	33.00				25	9.4	15.6	5.15	204
205	33.00				32	12.1	18.0	4.80	205
206	33.00				35	13.2	18.8	4.65	206
207	33.00				34	12.6	18.3	4.70	207
208	33.00				38	15.0	20.4	4.50	208
209	20.50			17.00	22	8.4	14.8	5.30	209
210	20.50				35	14.7	20.3	4.65	210
211	20.50				39	11.6	18.4	4.45	211
212	20.50				36	10.9	16.9	4.60	212
213	20.50				33	9.9	15.6	4.75	213
214	20.50				39	11.6	18.4	4.45	214
215	20.50				43	11.4	16.5	4.25	215
216	20.50				46	16.1	21.0	4.10	216
217	24.50			13.50	26	9.8	16.0	5.1	217
218	24.50				27	10.7	16.8	5.05	218
219	24.50				35	14.7	20.3	4.65	219
221					22	8.4	14.8	5.30	221
222					25	5.7	11.9	5.15	222
223					24	6.3	12.6	5.20	223
224					22	5.8	12.2	5.30	224
225					26	6.8	13.0	5.10	225
226					27	5.9	12.0	5.05	226
227					27	8.4	14.5	5.05	227
228					35	10.2	15.8	4.65	228
229					29	8.6	14.6	4.95	229
230					27	7.8	13.9	5.05	230
231					38	11.1	16.5	4.50	231
232					38	10.6	16.0	4.50	232
233					39	13.4	18.7	4.45	233
234	16.50			20.25	25	9.6	15.8	5.15	234
235	16.50				26	9.9	16.1	5.10	235

Rogers found that these three paints had about the same consistency as measured by the Stormer viscosimeter. He then found that 95-per-cent glycerin at 20° C. had practically the same consistency as the three standard paints. The Stormer viscosimeter was then adjusted so that it required two minutes for a complete rotation of the pointer in 95-per-cent glycerin at 20° C. The paints used were then made up by adding oil in fractions and making viscosity determinations after each addition, until the viscosity was 10 points greater than the standard; that is, until the dial went to 90 instead of 100 in two minutes. Tables I to IV (Plates IX, X and XI) give the final composition of the paints. Samples of these paints were



FIG. 1.—Single-Pigment Paints.

preserved in glass bottles and photographs taken at the end of about six months. Paints Nos. 212, 213 and 218 stuck to the sides of the bottles, but the others show the relative settling of the different paints very well. Figs. 1, 2 and 3 are reproductions of the photographs.

The paints were applied on both sides of the yellow poplar test boards 8 by 1 by 36 in., properly numbered by branding before painting. For the first coat, the paint as received from the Pratt Institute was thinned with a mixture of seven parts linseed oil and one part turpentine. This thinner was added to one quart of each paint on the basis of $1\frac{1}{2}$ pints of thinner to one gallon of paint. The first coat was spread as evenly as possible and ran about 650 sq. ft. to the gallon. On the first and second coats both sides of each board and all the edges were



FIG. 2. { Nos. 201-235, Two-Pigment Paints.
Nos. 301-321, Three-Pigment Paints.



FIG. 3. { Nos. 321-370, Three-Pigment Paints.
 { Nos. 401-406, Four-Pigment Paints.

painted. Before the third coat was applied the test boards were made into panels, three boards to a panel, by nailing strips $\frac{3}{4}$ by $1\frac{1}{2}$ by 24 in. on the ends of the boards. These panels, two panels of each number, were then painted on both sides and the exposed edges. The panels were crated and shipped by freight

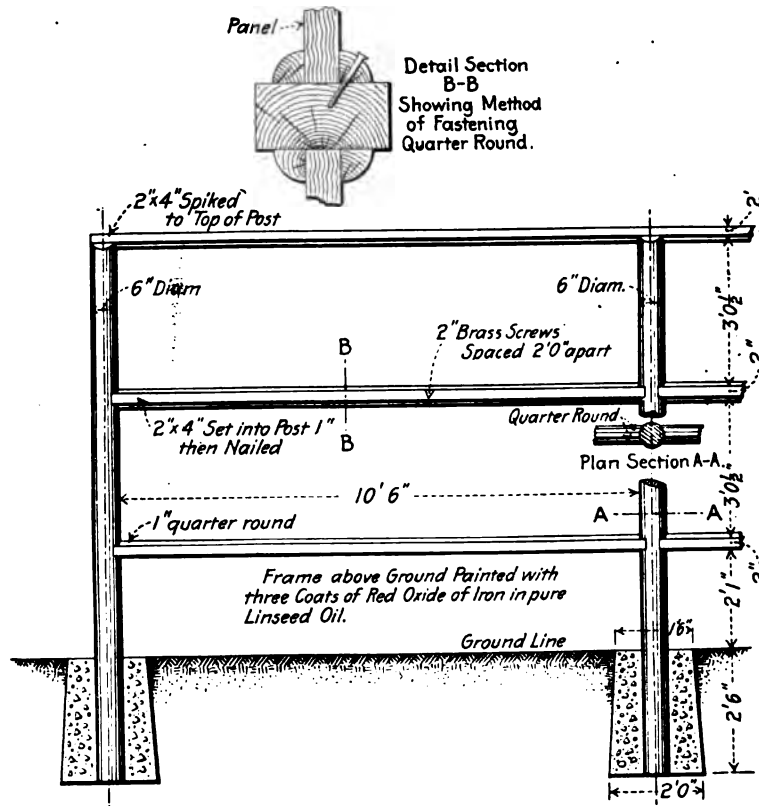


FIG. 4.—Showing Construction of Frame and Mounting of Test Pieces.

from Baltimore to Washington and hauled by wagon from Washington to the site of the exposure frame on the Experiment Farm of the United States Department of Agriculture at Arlington, Virginia. The method of paneling and crating adopted was a very efficient means of protecting the test pieces from injury in transit, and they were all received in good condition.

The frame for exposing the test pieces is located on the Arlington Farm, on a plot of ground south of the Miscellaneous Garden and east of the track of the Washington Southern Railroad. The railroad is above the level of the site of the frame. To the east of the frame is a marsh which is sometimes overflowed, but the frame is on ground sufficiently high to be safe from overflow. The frame runs north and south, consists of 26 panels, and is constructed as follows: Posts of red cedar 10 ft. 10½ in. long and 6 in. in diameter, are planted 2½ ft. deep in



FIG. 5.—Completed Test Fence.

1 : 2 : 3 concrete, and spaced 10 ft. 6 in. in the clear between posts. The posts are connected by three lines of 2 by 4-in. dressed Georgia pine stringers, the top stringers spiked to the tops of the posts, the middle and bottom stringers notched in and spiked with a clearance of 36½ in. The test pieces are attached to the frame by 1-in. quarter-round molding fastened by 2-in. brass screws. Fig. 4 shows the construction of the frame and method of mounting the test pieces. The frame and strips of molding were painted with three coats of red oxide of iron in linseed oil.

The crates containing the test pieces were opened on the ground near the frame, the end strips carefully removed, and the test pieces placed in the frame in the manner indicated above, so that duplicates are in vertical columns. The three boards constituting one test were placed next to one another in the frame, but narrow strips of white pine were used to separate the different tests. These strips are unpainted. Paint No. 101 is exposed on the north end of the frame and the succeeding paints extend south.



FIG. 6.—Completed Test Fence.

The painting was finished about July 15, 1912, and the boards were placed in position on the frame during the week ending August 31, 1912.

Figs. 5 and 6 are reproduced from photographs of the completed fence taken early in November, 1912.

Further tests of the pigments used, the results of which were received subsequent to the preparation of the above, are given below.

CLASSIFICATION TESTS OF PIGMENTS USED.

The thirteen pigments used in this test have been classified by the Thompson classifier¹ in the laboratory of the National Lead Co., and the results are given in Table V.

TABLE V.—CLASSIFICATION OF FINE PARTICLES.

	Sample No. 1.—Basic Lead Carbonate (Dutch Process White Lead).	Sample No. 2.—Basic Lead Carbonate (Carrier White Lead).	Sample No. 3.—Basic Lead Carbonate (Mild Process White Lead).	Sample No. 4.—Zinc Oxide (Florence Green Seal French Process Zinc Oxide).	Sample No. 5.—Zinc Oxide (XX American Process Zinc Oxide).	Sample No. 6.—Basic Lead Sulphate (Sublimed White Lead).
Coarse Portion.....	trace	trace	trace	trace	trace	none
Cone No. 1.....	6.1	5.1	3.7	1.8	0.3	0.9
Cone No. 2.....	0.6	2.5	0.5	6.5	0.9	0.7
Cone No. 3.....	5.6	2.7	2.0	5.7	2.1	2.1
Cone No. 4.....	8.2	4.3	4.5	9.6	3.1	3.2
Portion No. 5.....	79.5	85.4	89.3	76.4	93.6	93.1
Total.....	100.0	100.0	100.0	100.0	100.0	100.0

All values are percentages.

TABLE V.—CLASSIFICATION OF FINE PARTICLES (Continued).

	Sample No. 7.—Leaded Zinc Oxide (Leaded Oxide of Zinc).	Sample No. 8.—Siliceous Material (Silica).	Sample No. 9.—Silicate (Asbestine).	Sample No. 10.—Clay (L. G. V. China Clay).	Sample No. 11.—Calcium Carbonate (Extra Gilders Whiting, Bolted).	Sample No. 12.—Calcium Sulphate.	Sample No. 13.—Barium Sulphate (Cream Floated Lead Bloom—Water Floated Barytes).
Coarse Portion.	none	1.8	4.8	trace	0.3	8.7	trace
Cone No. 1....	0.2	16.8	17.8	0.9	2.5	16.4	13.2
Cone No. 2....	0.5	13.1	6.7	5.5	1.9	5.7	14.2
Cone No. 3....	1.3	7.6	9.5	9.5	5.4	7.0	13.0
Cone No. 4....	3.7	12.0	10.6	10.7	7.7	14.0	10.8
Portion No. 5..	94.3	48.7	50.6	73.4	82.2	48.2	48.8
Total.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0

All values are percentages.

¹ For a description of this classifier, see "The Classification of Fine Particles According to Size," by G. W. Thompson, *Proceedings, Am. Soc. Test. Mats.*, Vol. X, p. 601 (1910).

"Coarse portion," as here termed, is the material which will not pass through a No. 21 silk bolting cloth screen. "Portion No. 5" is obtained by difference. In each case the flow of kerosene was varied according to the specific gravity of the pigment. The amount used was likewise varied.

Microphotographs of the original pigments and the various classified portions were made in the Microchemical Laboratory of the Bureau of Chemistry and appear as Figs. 7 to 92 (pages 434-447). They were all made by transmitted light with a magnification of 200 diameters.

The following comments are made by the Microchemical Laboratory:

"Most of the pictures were taken from mounts of the powder with linseed oil. A few, however, were mounted in Canada balsam; and from the results obtained, better results might have been obtained had Canada balsam been used on all the samples. This would have been of particular advantage with pigments Nos. 1 to 7, inclusive, for it appears that there is less tendency to flocculate in Canada balsam than in linseed oil.

"Another point to which attention should be called is that in many of the samples of pigments Nos. 1 to 7, there were fairly large particles mixed with much fine material, and an examination of the larger particles indicates that they were usually aggregates of the small ones. Therefore, in making the mounts many of these large particles broke up into finer portions and the pictures may not show the state of aggregation of the particles as they originally came from the separating cones. This is of vital importance in making a series of pictures such as the present one, where it is the purpose to obtain representation of the size of the particles, and it is believed that about the only way to get satisfactory pictures is to mount and photograph the substance directly as it comes from the cones, as the subsequent washing and drying is likely to produce aggregation, making later examination uncertain. In making this series of pictures we have sought to make as accurate representations as possible, but we feel that they may not represent truthfully the size of the particles or aggregates as they came originally from the cones.

"In many samples it seems that the pieces are aggregates rather than individual particles. In the first place, an exami-

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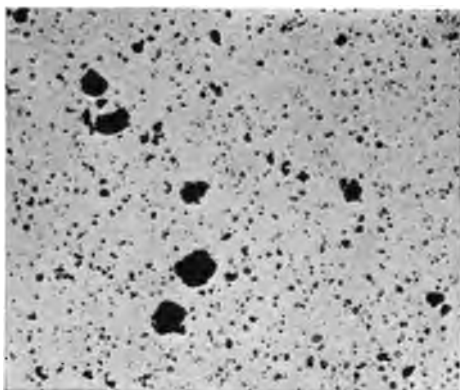


FIG. 7.—Original.

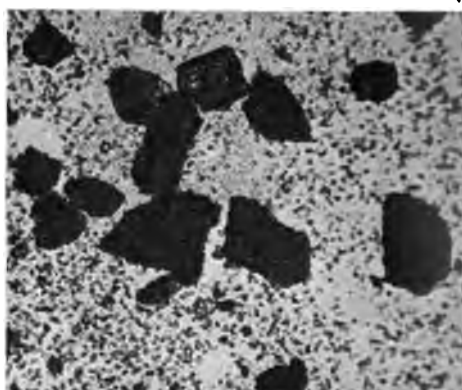


FIG. 8.—Cone No. 1.

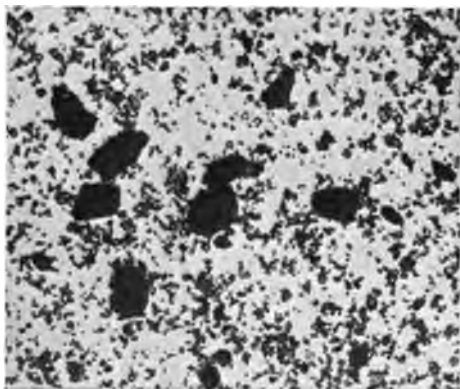


FIG. 9.—Cone No. 2.

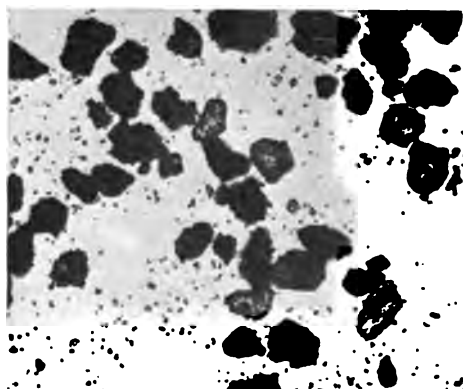


FIG. 10.—Cone No. 3.

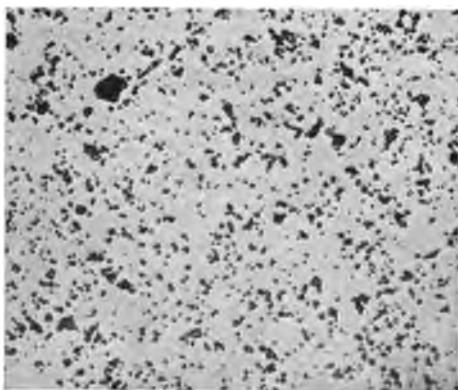


FIG. 11.—Cone No. 4.

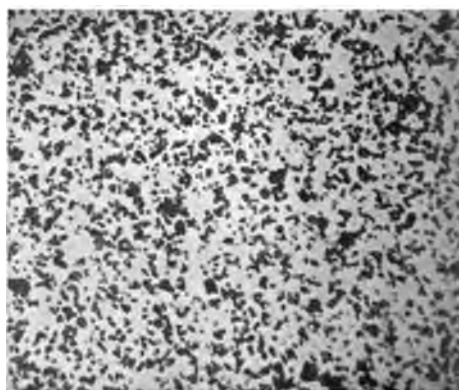


FIG. 12.—Portion No. 5.

SAMPLE NO. 1.—BASIC LEAD CARBONATE (DUTCH PROCESS WHITE LEAD) $\times 200$.

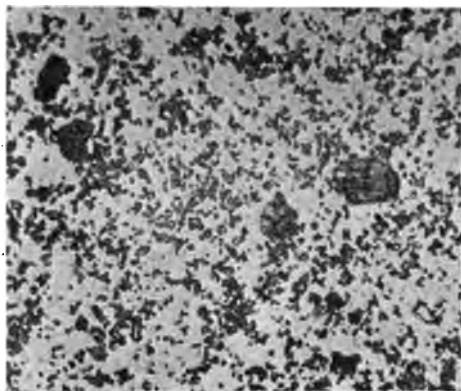


FIG. 13.—Original.

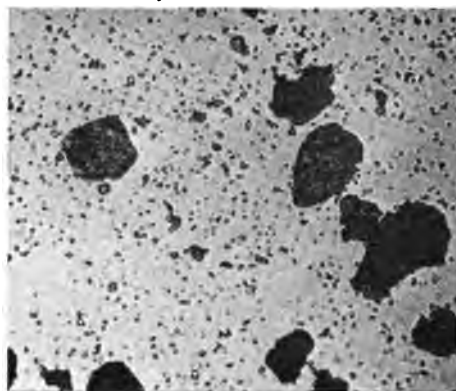


FIG. 14.—Cone No. 1.

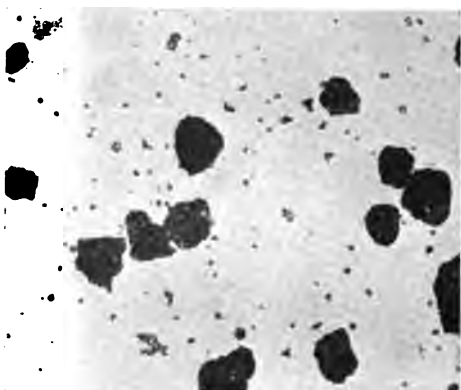


FIG. 15.—Cone No. 2.

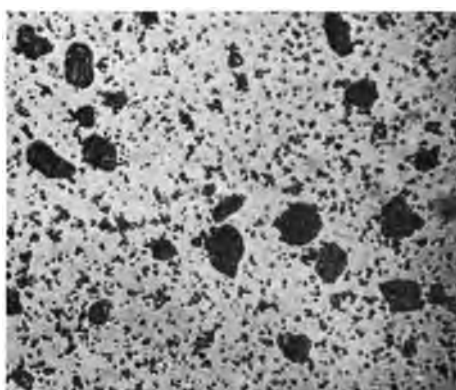


FIG. 16.—Cone No. 3.

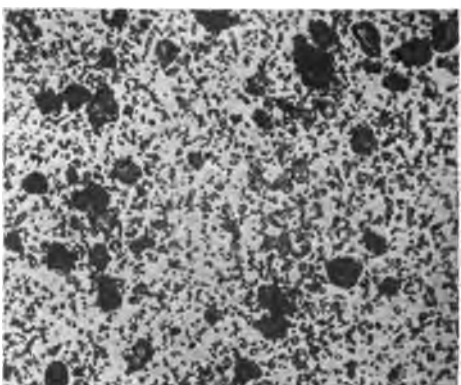


FIG. 17.—Cone No. 4.

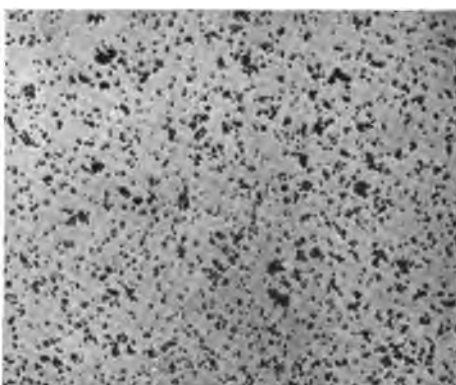


FIG. 18.—Portion No. 5.

SAMPLE NO. 2.—BASIC LEAD CARBONATE (CARTER WHITE LEAD) $\times 200$.

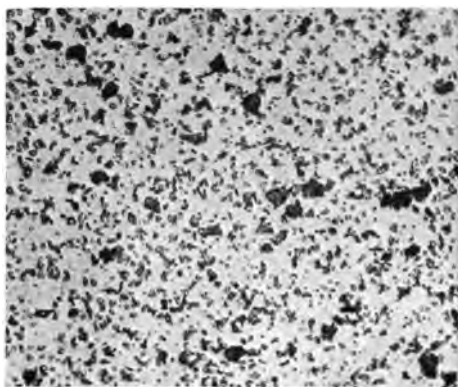


FIG. 19.—Original.

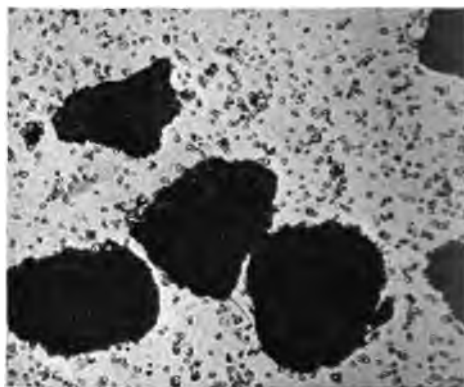


FIG. 20.—Cone No. 1.

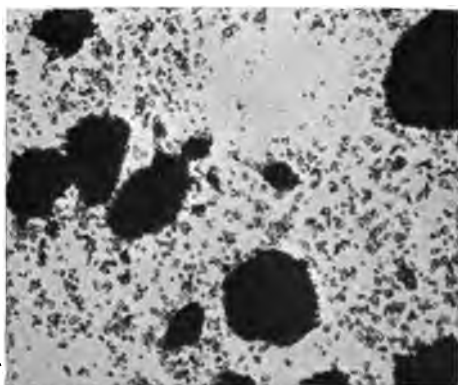


FIG. 21.—Cone No. 2.

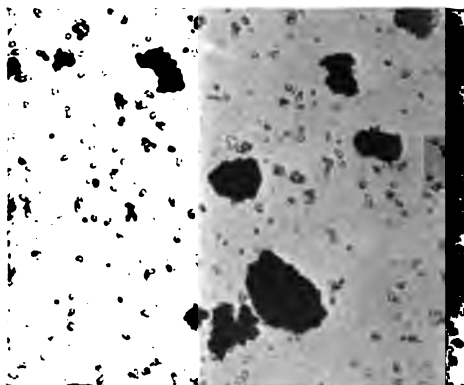


FIG. 22.—Cone No. 3.

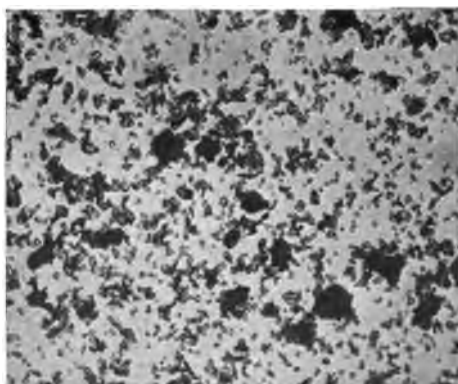


FIG. 23.—Cone No. 4.

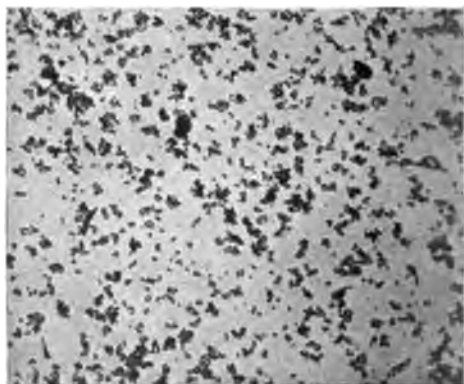


FIG. 24.—Portion No. 5.

SAMPLE NO. 3.—BASIC LEAD CARBONATE (MILD PROCESS WHITE LEAD) $\times 200$.

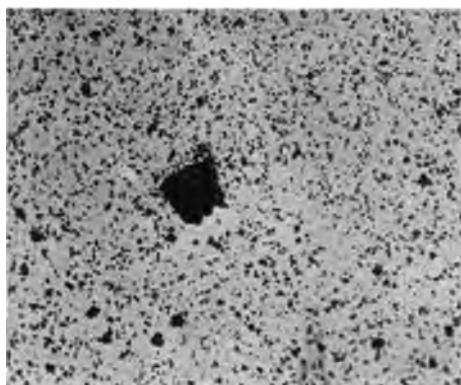


FIG. 25.—Original.

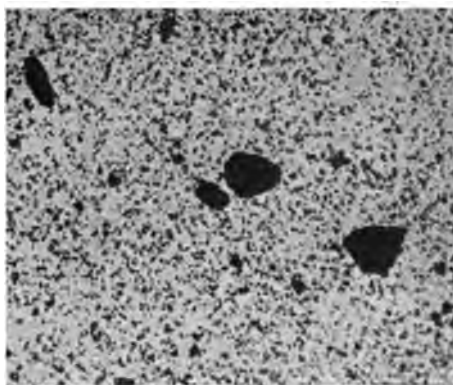


FIG. 26.—Cone No. 1.

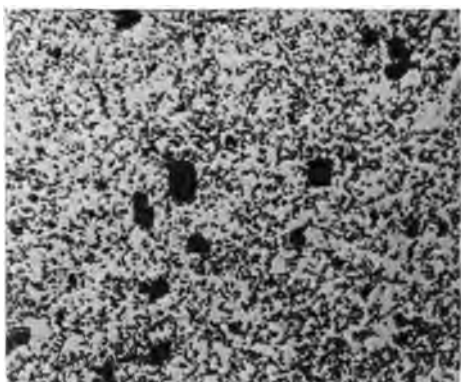


FIG. 27.—Cone No. 2.

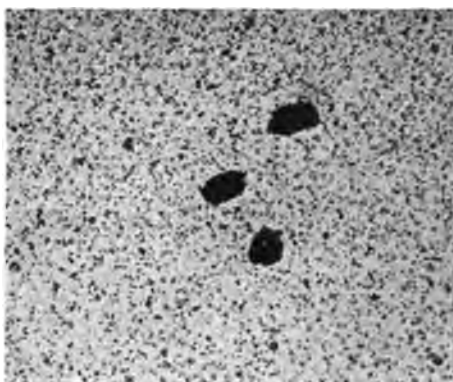


FIG. 28.—Cone No. 3.

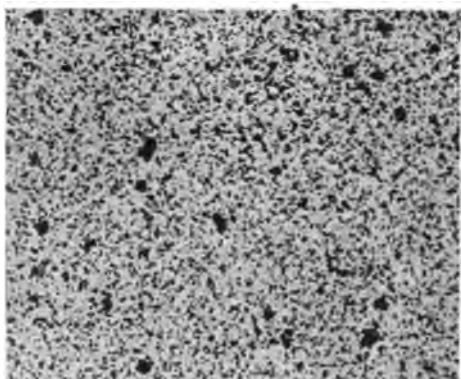


FIG. 29.—Cone No. 4.

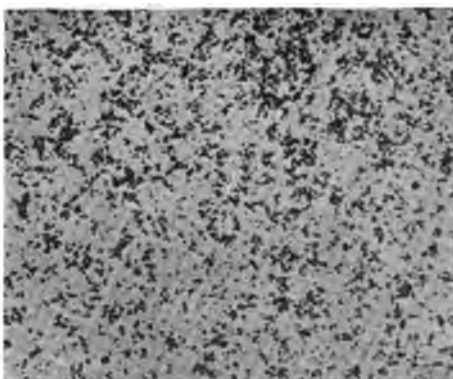


FIG. 30.—Portion No. 5.

SAMPLE NO. 4.—ZINC OXIDE (FLORENCE GREEN SEAL, FRENCH PROCESS ZINC OXIDE) $\times 200$.

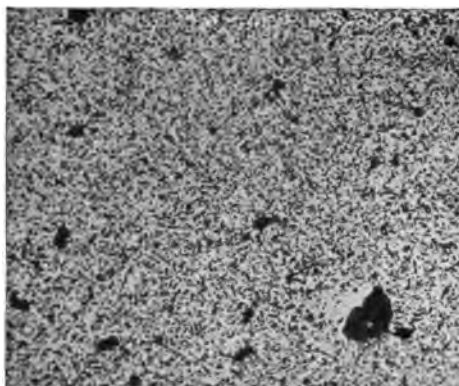


FIG. 31.—Original.

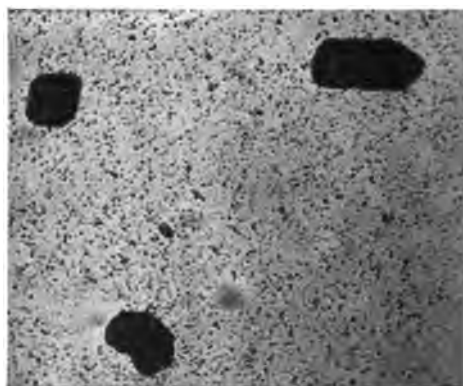


FIG. 32.—Cone No. 1.

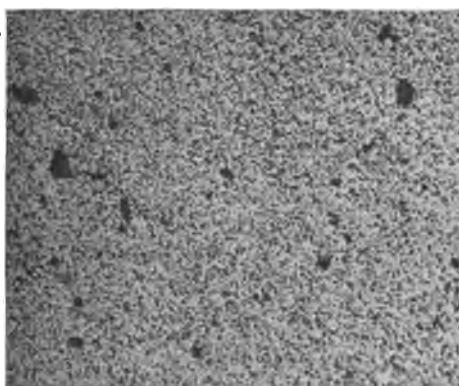


FIG. 33.—Cone No. 2.

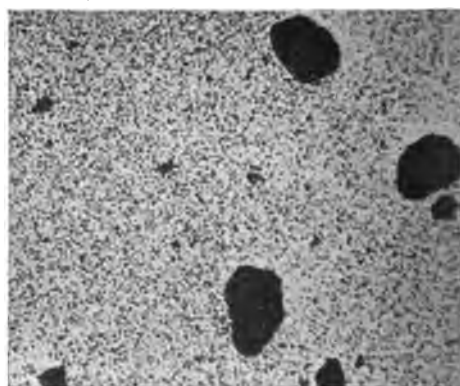


FIG. 34.—Cone No. 3.

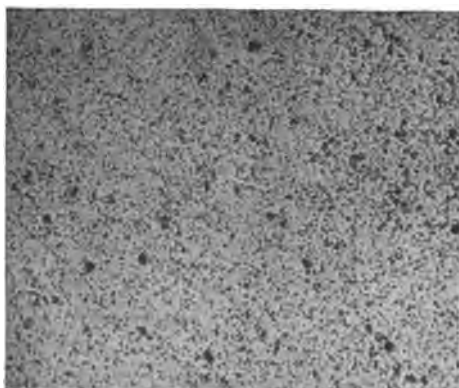


FIG. 35.—Cone No. 4.



FIG. 36.—Portion No. 5.

SAMPLE NO. 5.—ZINC OXIDE (XX AMERICAN PROCESS ZINC OXIDE) $\times 200$.

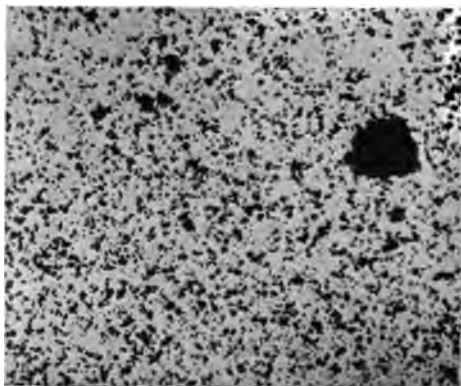


FIG. 37.—Original.

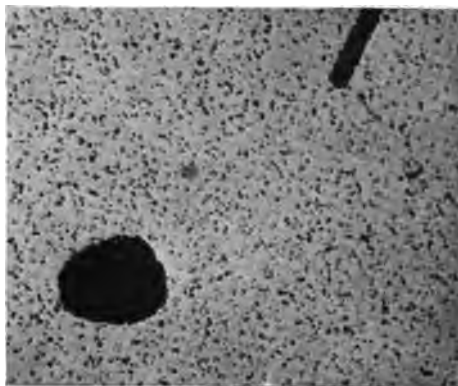


FIG. 38.—Cone No. 1.

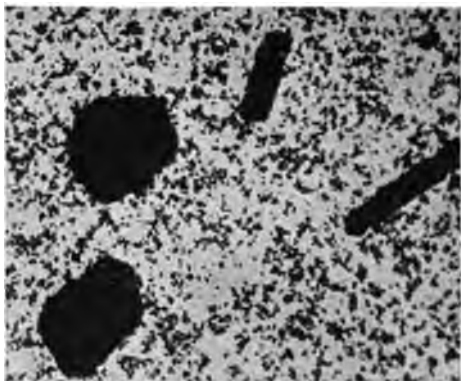


FIG. 39.—Cone No. 2.

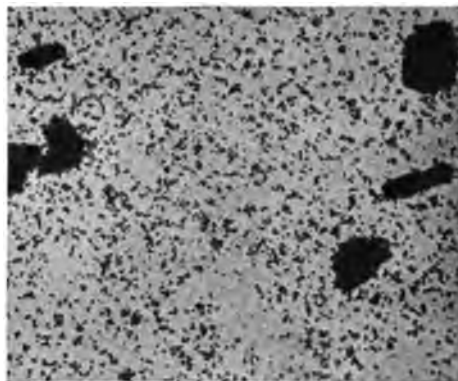


FIG. 40.—Cone No. 3.

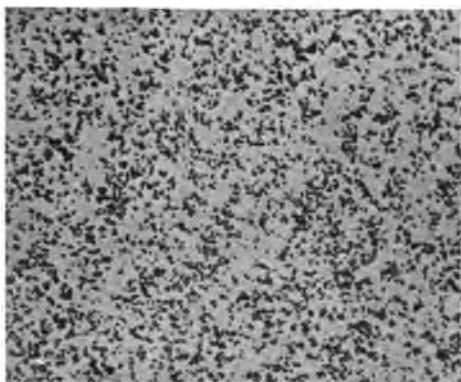


FIG. 41.—Cone No. 4.

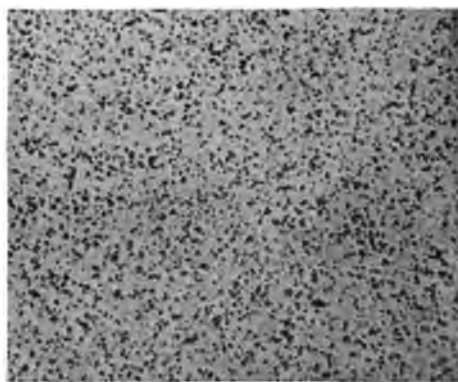


FIG. 42.—Portion No. 5.

SAMPLE NO. 6.—BASIC LEAD SULPHATE (SUBLIMED WHITE LEAD) $\times 200$.

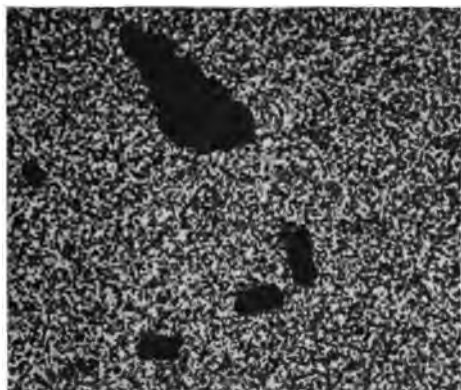


FIG. 43.—Original.

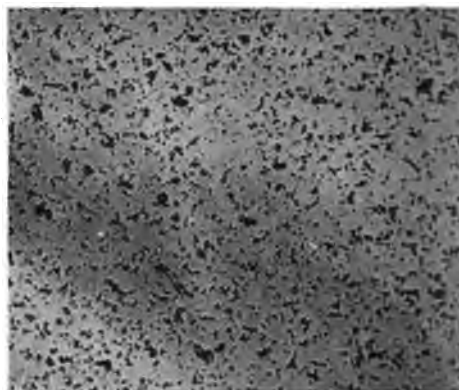


FIG. 44.—Cone No. 1.

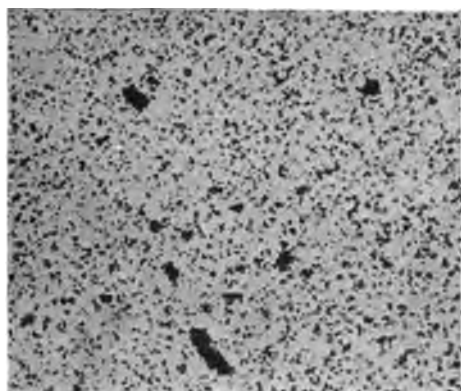


FIG. 45.—Cone No. 2

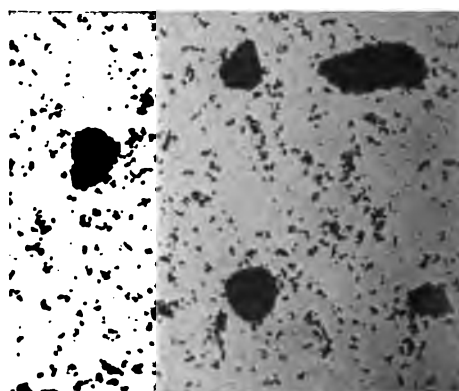


FIG. 46.—Cone No. 3.

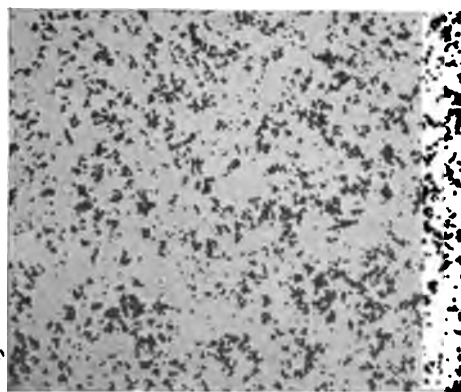


FIG. 47.—Cone No. 4.

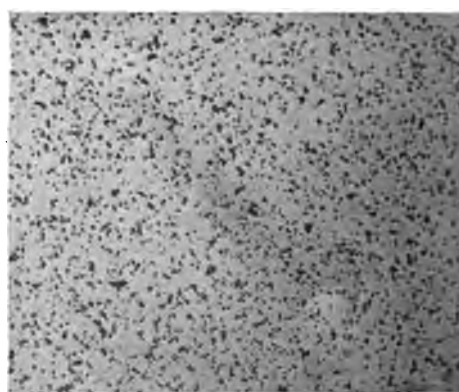


FIG. 48.—Portion No. 5.

SAMPLE NO. 7.—LEADED ZINC OXIDE (LEADED OXIDE OF ZINC) $\times 200$.

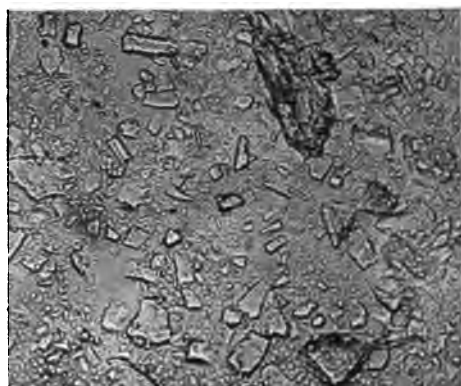


FIG. 49.—Original.

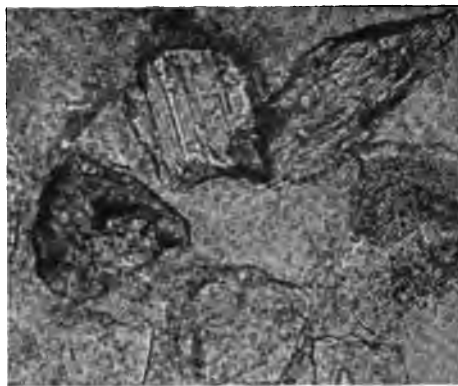


FIG. 50.—Coarse Portion



FIG. 51.—Cone No. 1.



FIG. 52.—Cone No. 2.



FIG. 53.—Cone No. 3.



FIG. 54.—Cone No. 4.

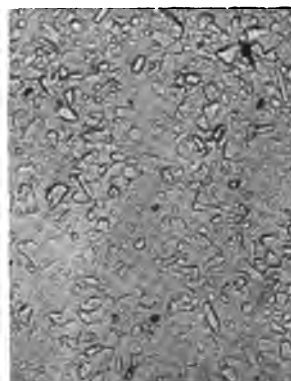


FIG. 55.—Portion No. 5.

SAMPLE NO. 8.—SILICEOUS MATERIAL (SILICA) $\times 200$.

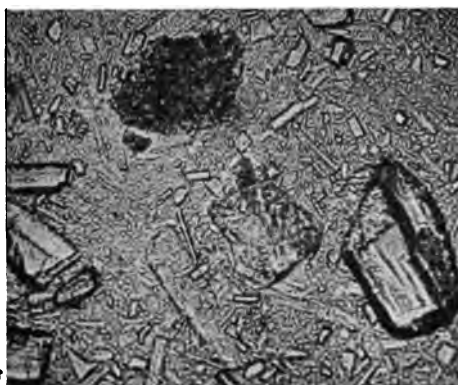


FIG. 56.—Original.

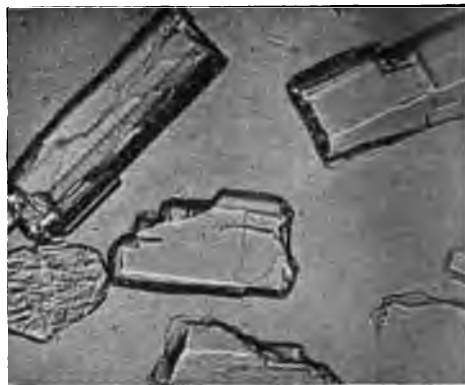


FIG. 57.—Coarse Portion.



FIG. 58.—Cone No. 1.



FIG. 59.—Cone No. 2.



FIG. 60.—Cone No. 3.

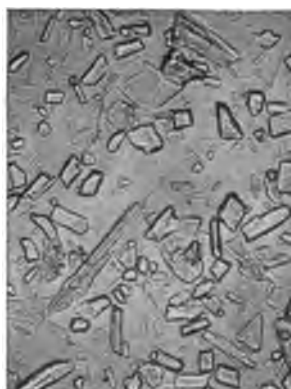


FIG. 61.—Cone No. 4.



FIG. 62.—Portion No. 5.

SAMPLE NO. 9.—SILICATE (ASBESTINE) $\times 200$.

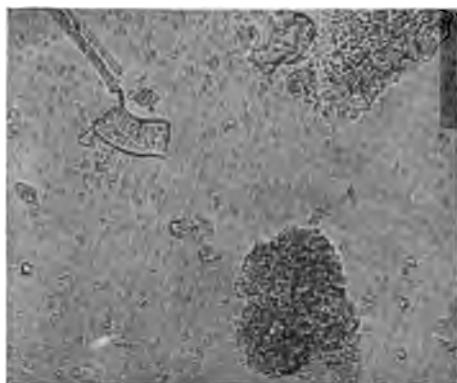


FIG. 63.—Original.

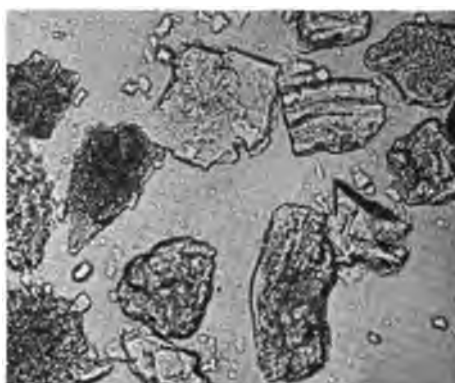


FIG. 64.—Cone No. 1.



FIG. 65.—Cone No. 2.

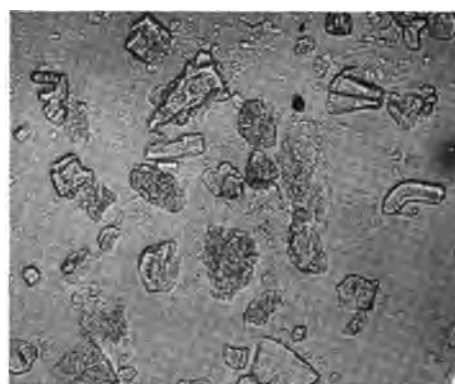


FIG. 66.—Cone No. 3.

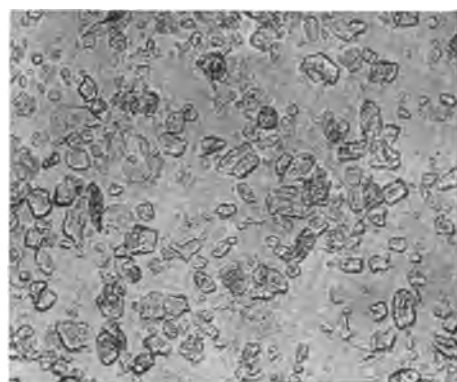


FIG. 67.—Cone No. 4.



FIG. 68.—Portion No. 5.

SAMPLE No. 10.—CLAY (L. G. V. CHINA CLAY) $\times 200$.



FIG. 69.—Original.

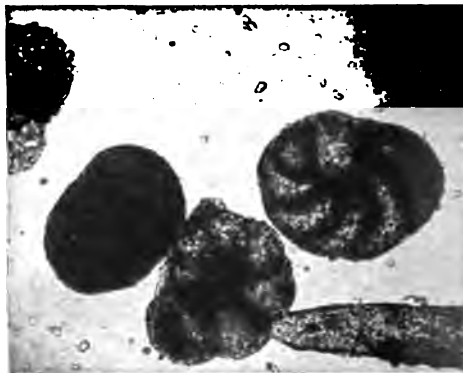


FIG. 70.—Coarse Portion.

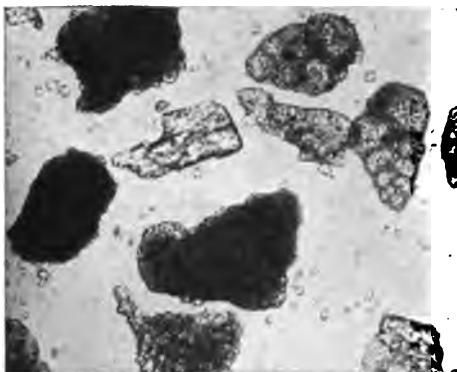


FIG. 71.—Cone No. 1.

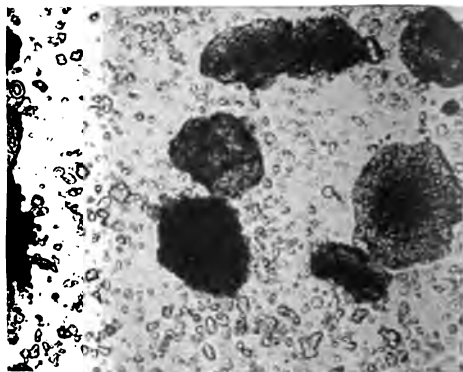


FIG. 72.—Cone No. 2.

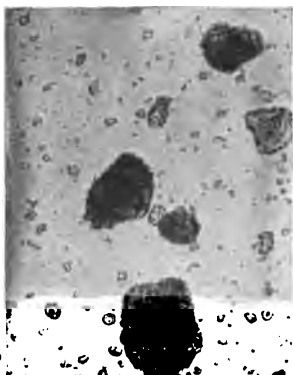


FIG. 73.—Cone No. 3.

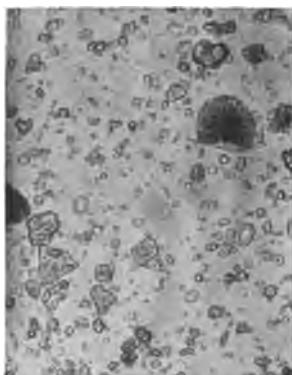


FIG. 74.—Cone No. 4.

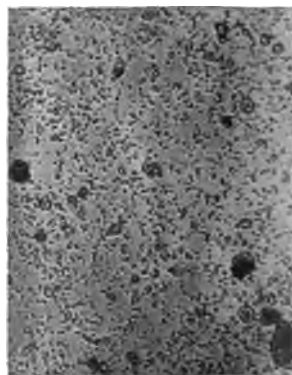


FIG. 75.—Portion No. 5.

SAMPLE NO. 11.—CALCIUM CARBONATE (EXTRA GILDERS WHITING, BOLTED) $\times 200$.

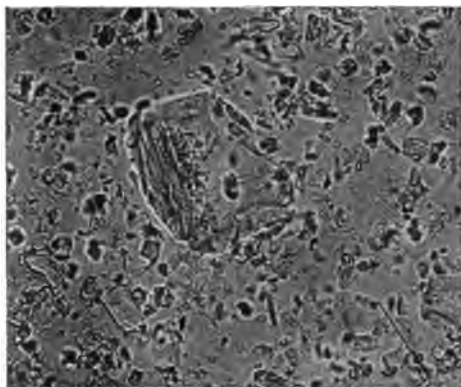


FIG. 76.—Original.

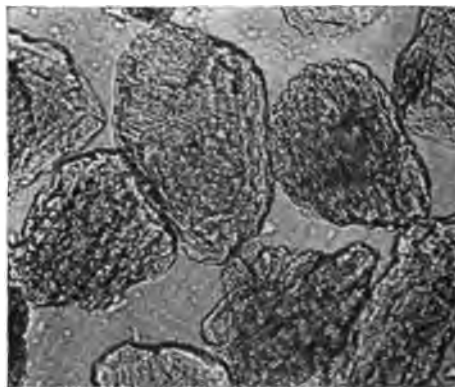


FIG. 77.—Coarse Portion.



FIG. 78.—Cone No. 1.

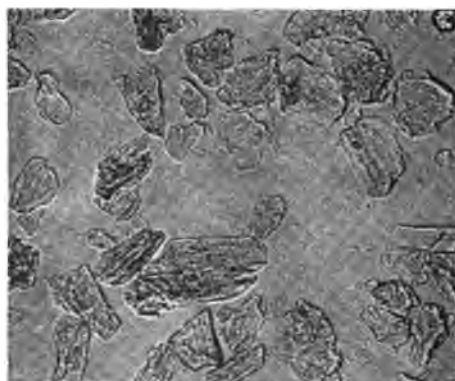


FIG. 79.—Cone No. 2.

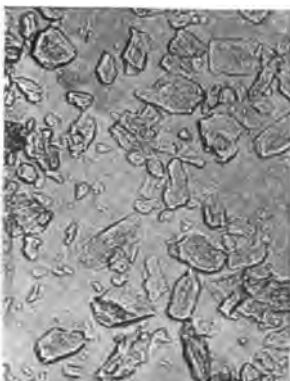


FIG. 80.—Cone No. 3.

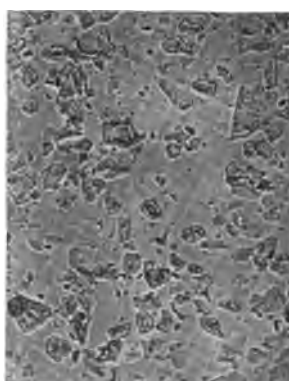


FIG. 81.—Cone No. 4.



FIG. 82.—Portion No. 5.

SAMPLE NO. 12.—CALCIUM SULPHATE $\times 200$.

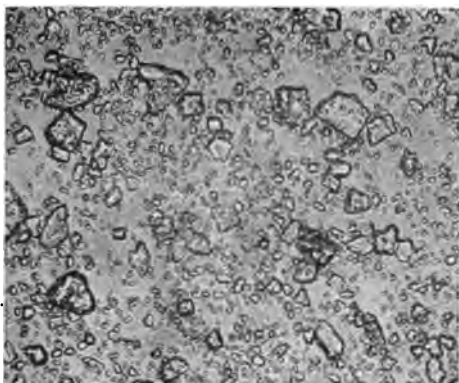


FIG. 83.—Original.

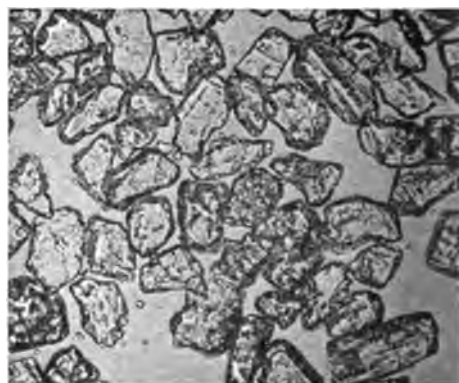


FIG. 84.—Cone No. 1.

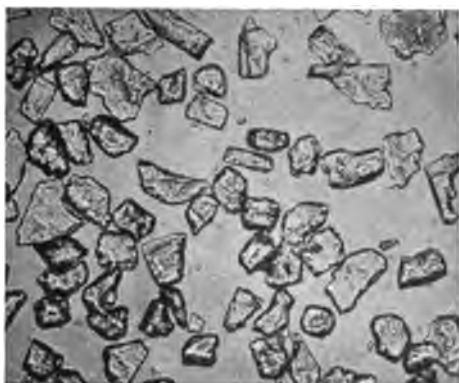


FIG. 85.—Cone No. 2.

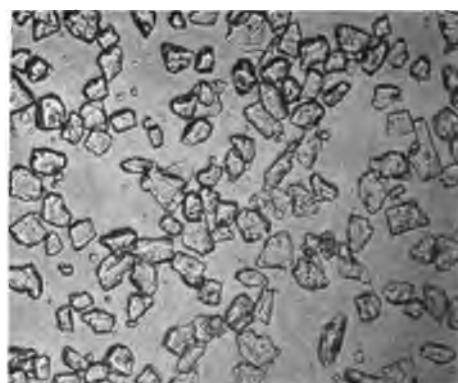


FIG. 86.—Cone No. 3.

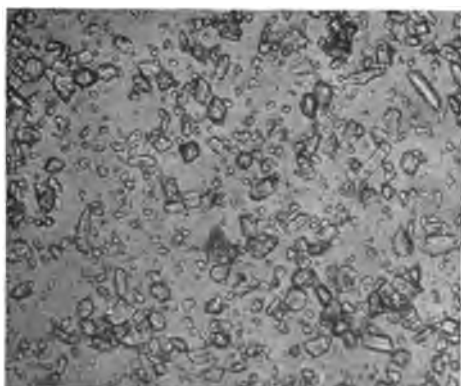


FIG. 87.—Cone No. 4.

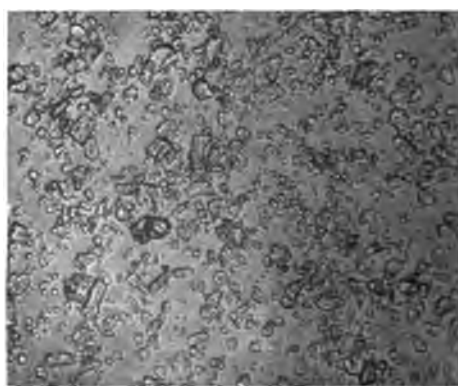


FIG. 88.—Portion No. 5.

SAMPLE NO. 13.—BARIUM SULPHATE (CREAM FLOATED LEAD BLOOM, WATER-FLOATED BARYTES) $\times 200$.

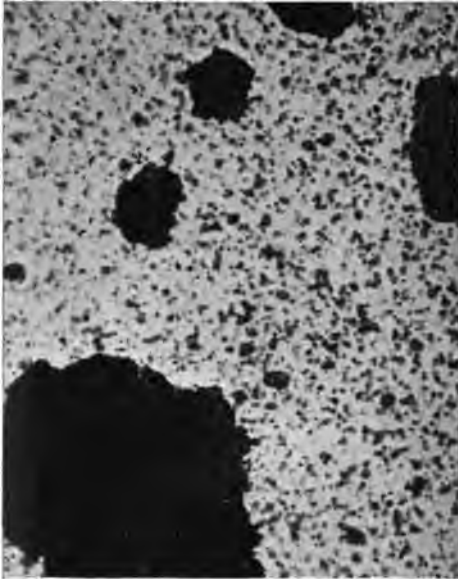


FIG. 89.—Sample No. 1, mounted on slide with as little breaking of particles as possible. Cone No. 2; $\times 200$.

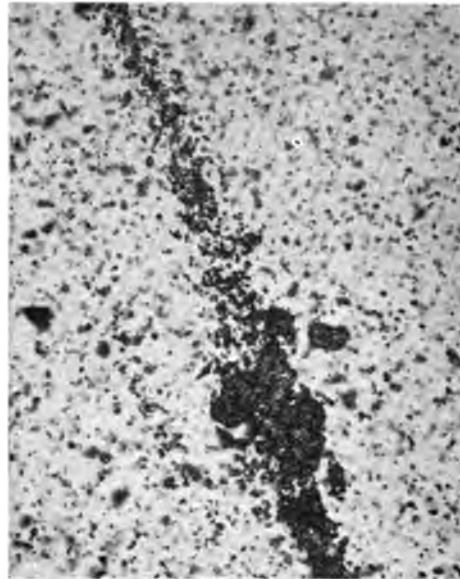


FIG. 90.—Same slide as shown in Fig. 89 but taken after cover glass had been moved, causing the aggregate to start breaking into component fine particles. $\times 200$.

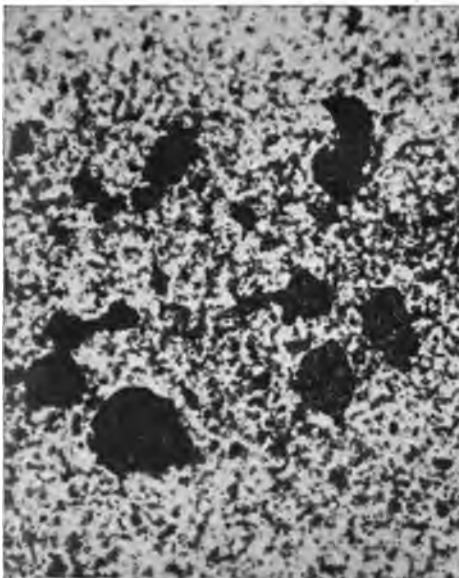


FIG. 91.—Same slide as shown in Fig. 89 but in which a larger piece is shown breaking up. $\times 200$.

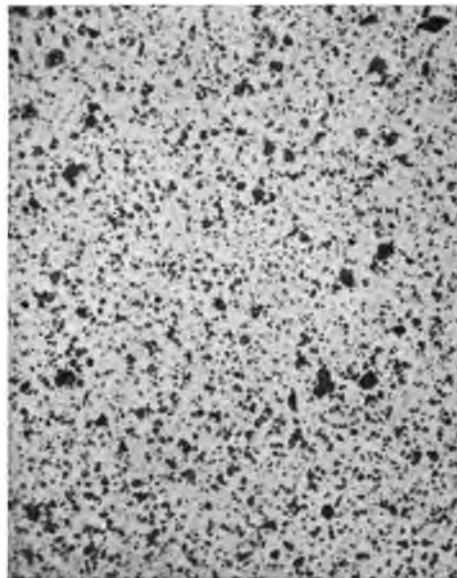


FIG. 92.—Same slide as shown in Fig. 89, but taken after disintegration was complete. $\times 200$.



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